Lakes: the mirrors of the earth

BALANCING ECOSYSTEM INTEGRITY AND HUMAN WELLBEING

WLC15 PERUGIA2014

Proceedings of **15th world lake conference**

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ISBN: 978-88-96504-04-8 (print)
ISBN: 978-88-96504-07-9 (online)

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Volume 2: Proceedings of the 15th World Lake Conference

Edited by

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Published by **Science4Press**

Consorzio S.C.I.R.E. E (Scientific Consortium for the Industrial Research and Engineering)
www.consorzioscire.it

Printed in Italy

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ECOLOGY AND BIOLOGY OF LAKES & INLAND WATERS

Plasmid-Mediated Transfer of Heavy metal tolerance gene to Escherichia coli isolated from Fatehsagar lake, Udaipur, Rajasthan, India

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Keywords: Fateh Sagar, *Pseudomonas*, *E. coli.*, heavy metal, bioremediation

Introduction

Heavy metal pollution in soils and water bodies is the most serious environmental problem and has significant implications for human health. Heavy metals are major pollutants in marine, ground, industrial and even treated wastewater (Valdman et al. 2001). High concentrations of toxic heavy metals present in the wastewater directly lead to both contamination of receiving water bodies and deleterious impact on aquatic life (Moten & Rehman, 1998). Udaipur is famous all over the world for its enchanting lakes. Fateh Sagar Lake is one of the artificial lake of Udaipur, Rajasthan, India. It is one of the major sources of drinking water to the city of Udaipur which is increasingly being contaminated with xenobiotic materials. Heavy metals are introduced into the aquatic system as a result of various human activities like mining, smelting, processing, release of industrial effluents and domestic waste water. Heavy metal contamination thus poses a serious threat to both the ecosystem and human. It requires expensive cleanup costs. Bioremediation based on microorganisms, plants or other biological systems offers a cost-effective and environment friendly method for metal clean-up (Haferburg & Kothe, 2010; Milner & Kochian, 2008). Varieties of mechanisms exist in microorganisms to deal with high concentrations of heavy metals and often are specific to one or a few metals (Silver & Misra, 1988; Nies, 2003). These high concentrations of metals are evolutionary pressures selecting for microorganisms tolerant to these metals. Metal tolerance may be conferred to these organisms by mobile genetic elements such as plasmids. The present study was aimed to determine heavy metal tolerance in *Pseudomonas* and to transfer the plasmid DNA to heavy metal sensitive *E. coli* FS-1 previously isolated from fresh water lake Fatehsagar of Udaipur, (Rajasthan).

Materials and methods

Source of bacteria

Heavy metal tolerant bacterial isolates *Pseudomonas aeruginosa* HMR1, previously isolated from heavy metal contaminated sites of Zawar, Udaipur (Bhojiya & Joshi, 2012) and heavy metal sensitive *E. coli* FS-1, previously isolated and identified from fresh water Lake Fateh Sagar of Udaipur were used in this study.

Determination of heavy metal sensitivity in E.coli *FS-1*

E. coli FS-1 was grown on nutrient agar supplemented with 1mM of zinc ions and incubated at 37°C for 48h.

Determination of minimum inhibitory concentrations (MIC) of heavy metals

The MIC of the heavy metals($ZnSO_4.7H_2O$, $Pb(NO_3)_2$ and $NiCl_2.6H_2O$) for *Pseudomonas aeruginosa* HMR1 was determined by the plate dilution method as adopted by Malik & Jaiswal (2000). In this test, 10 µl of a liquid broth overnight broth culture was applied onto duplicate agar plates containing the appropriate heavy metal salts and incubation was done at 37°C for 48h. The lowest concentration of the metal, which inhibits the bacterial growth, was considered as MIC.

Plasmid Screening and Transformation

Plasmid DNA was isolated from heavy metal tolerant bacterial strain *Pseudomonas aeruginosa* HMR1 by the alkaline lysis method as described by Birnboim & Doly (1979). The isolated plasmid DNA was visualized and detected by Agarose gel electrophoresis. The heavy metal sensitive *E. coli* FS-1 strain was used as the host for transformation of plasmid DNA isolated from the heavy metal tolerant bacterial strain *Pseudomonas aeruginosa* HMR1. Transformed cells were selected by inoculating the culture on nutrient agar supplemented with 1mM zinc ions. The transformant were also analyzed for the plasmid content by the alkaline lysis method and compared with the plasmid profile of the wild-type strains through Agarose gel electrophoresis.

Results

Fresh water lake isolate *E. coli* FS-1 showed no growth on nutrient agar supplemented with 1mM of zinc ions. Fairly high tolerance was observed for *Pseudomonas aeruginosa* HMR1 towards elevated concentration of heavy metals ($ZnSO_4.7H_2O$, $Pb(NO_3)_2$ and $NiCl_2.6H_2O$). The well defined colonies were observed after 48 h of incubation in the medium up to 10mM concentration of zinc ions, 1mM concentration of lead ions and 1mM concentration of nickel ions. *Pseudomonas aeruginosa* HMR1 didn't show any growth on high concentration of zinc (12.5 and 15 mM), lead (1.25 and 1.5 mM) and nickel (1.25 and 1.5 mM) (Table 1).

S.No	Zinc ions concentration (mM)	P. aeruginosa HMR1	Lead ions concentration (mM)	P. aeruginosa HMR1	Nickel ions concentration (mM)	P. aeruginosa HMR1
1.	0	+++	0	+++	0	+++
2.	1	++	0.25	++	0.25	++
3.	2.5	+	0.5	+	0.5	+
4.	5	+	1.0	+	1.0	+
5.	7.5	+	1.25	-	1.25	-
6.	10	+	1.5	-	1.5	-
7.	12.5	-				
8.	15	-				

+++ luxurious growth, ++ good growth, + less growth, - No growth

Table 1: Heavy metal tolerance of *Pseudomonas aeruginosa* HMR1

The single plasmid DNA of size approximately 23 Kb was isolated from the heavy metal tolerant *Pseudomonas aeruginosa* HMR1. It was transformed to sensitive cells of *E. coli* FS1 after heat shock and cold shock treatments. Plasmid DNA from the transformed *E. coli* FS1 and heavy metal tolerant bacteria *Pseudomonas aeruginosa* HMR1 were subjected to agarose gel electrophoresis. Transformant harboured a plasmid of the same size as that in *Pseudomonas aeruginosa* HMR1 (Fig. 1).

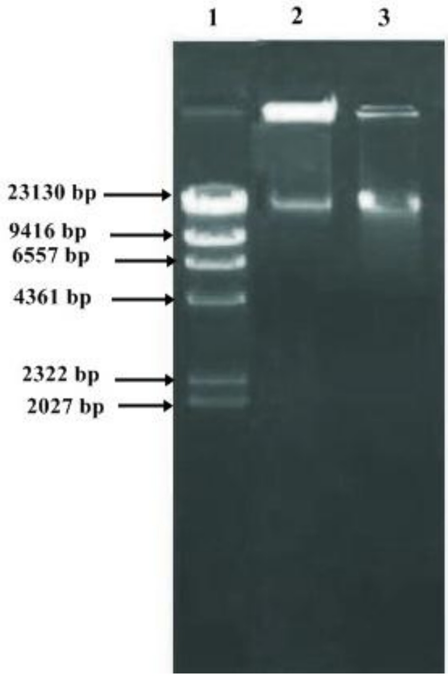

Fig. 1: Plasmid DNA profile of *Pseudomonas aeruginosa* HMR1. Lane 1 = λ Hind III digest molecular weight marker; Lane 2 = *P. aeruginosa* HMR1; Lane 3 = Transformed *E. coli* FS-1

Discussion

Pseudomonas strains are predominant bacteria which could tolerate high concentrations of the heavy metals. In the present study, *Pseudomonas aeruginosa* HMR1 has shown resistance to Zn, Pb and Ni. In *Pseudomonas aeruginosa* HMR1 fairly high MIC of 10mM was observed for zinc ions. This range of MIC is similar to *Pseudomonas aeruginosa* isolated from polluted sites in Assiut city, Egypt for which MIC was 9.2mM (Hassan et al. 2008). Hussein et al. (2004) isolated Pseudomonas from sewage treatment plant which was resistant to 1mM of Nickel ions. MIC for nickel is quiet similar to our study. Pseudomonas aeruginosa HMR1 shows MIC of 1mM for lead ions which is comparable with that of *Pseudomonas aeruginosa* AD4 isolated by Durve et al. (2013).

In the present study plasmid DNA isolated from *Pseudomonas aeruginosa* HMR1 that could tolerate high concentrations of heavy metals, was transformed into *E. coli* FS-1. The new genetically modified strain may be resistant to high concentrations of various heavy metals. Krishnaswamy & Wilson (2000) reported genetically engineered *E. coli* JM109 with known plasmids of different traits and genes could be resistant to high levels of metals. Furthermore, plasmids might be the source of genes that provided metal resistance in *E. coli* FS-1. In the present study metal resistance may be due to the presence of the plasmid. Further these transformed *E. coli* FS-1 strain could be exploited for the bioremediation of heavy metal polluted environment.

Acknowledgment

The first author gratefully acknowledges the financial support received from Maulana Azad National Fellowship, University Grant Commission, New Delhi.

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Influence of light wavelength and intensity on geosmin production of *Streptomyces coelicolor* A3(2)

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Keywords: Actinomycetes, musty odor, geosmin

Introduction

In recent years, the occurrence of musty odor concerns originated from microorganisms in freshwater environments like as lakes, rivers, and reservoirs has been reported in all over the world (ex. Juttner and Watson 2007). Actinomycetes are known one of the causal microorganisms to produce geosmin and 2-methylisoborneol (2-MIB), both are responsible for musty odor in fresh waters. Waterworks are strongly interested in when geosmin production occurs in the reservoir, because musty odor compounds can be perceived by human being at very low concentration level (ng/L) (Young et al. 1996), and it is ineffective to remove by conventional water supply treatment processes such as coagulation, sedimentation, filtration and chlorination (Bruce et. al. 2002). Establishment of effective removal methods is essential for reservoirs in situ, but it is still unclear what environmental factors control the production of these compounds in aquatic environments.

Geosmin biosynthesis by *Streptomyces coelicolor* A3(2), a strain whose genome has been fully sequenced (Bentley et al. 2002), is studied (Cane et al. 2003). But the biosynthesis trigger of geosmin production is still unclear. Light is one of the important trigger factors for metabolic response of actinomycetes; as have reported that *S. coelicolor* A3(2) produced carotenoids when exposed under blue light (2.4 µmol m^{-2} s^{-1}), but didn't produce under red light (2.4 µmol m^{-2} s^{-1}) (Takano et al. 2005, Takano et al. 2006). Both of carotenoid and geosmin are terpenoids. Furthermore, isopentenylpyrophosphate (IPP) is common precursor of geosmin and carotenoid. Therefore, it is assumed that light influences on geosmin production by actinomycetes. Based on these backgrounds, we have studied what kind of environmental factors influence on geosmin production of actinomycetes. Here, we reported that the results of plate culture experiments under different light irradiation conditions (wavelengths and intensities) to elucidate the factors that influence on geosmin production of *S. coelicolor* A3(2).

Materials and methods

S. coelicolor A3(2) was pre-cultured at 28°C for 2 days in 100 mL YMPD medium (2.0 g yeast extract, 2.2 g meat extract, 4.0 g Bacto peptone, 2.0 g NaCl, 1.0 g $MgSO_4 \cdot 7H_2O$, 1.0 g glucose, pH 7.2, per litter) in a 300 mL baffled Erlenmeyer flask, and incubated with shaking at 120 rpm under dark condition. All medium pH were adjusted with NaOH solution before autoclaving. Cells from each 1 mL of cultured medium were harvested by centrifugation (5,000 × *g*, 5 min) and were washed twice with BS medium without carbon source (BS negative; 2.0 g $(NH_4)_2SO_4$, 2.0 g NaCl, 1.0 g $MgSO_4 \cdot 7H_2O$, 0.5 g K_2HPO_4, 0.05 g $FeSO_4 \cdot 7H_2O$, pH 8.0, per litter). After homogenized weakly by 1 mm glass beads with 1 mL of sterilized distillated water using Fast Prep system (Thermo Savent), cell suspension at a final concentration of 1×10^5 CFU/mL were spread on SFM agar plate (20 g soybean flour, 20 g mannitol, 15 g ager, pH 8.0, per litter). All plates were cultured at 28 °C for 7 days under specified light conditions or dark condition. Under light condition, we used white, blue (470 nm), green (525 nm), and red (660 nm) LED light equipment for illuminating at 1, 10, 20, 30 μmol m^{-2} s^{-1} onto the plates respectively. After 7 days cultivation, 5.0 mL of methanol was directly added to each plate for geosmin extraction, and then the plates were kept at room temperature for 30 min. 1.0 mL of methanol geosmin extracts was collected in glass tube and added 2.0 mL of n-hexane. After that, these tubes were stirred for 30 min and then centrifuged at 800 × *g* for 30 min to separate the n-hexane and methanol layer. The n-hexane layer was carefully collected and filtered through in a Pasteur pipette packed by Na_2SO_4 for dehydration (David and He 2006, Komatsu et al. 2008). The extracts were analyzed by GC-MS QP2010 plus (Shimadzu Co Ltd. Japan) with AOC-20is series autosampler (Shimadzu Co Ltd. Japan) for measuring geosmin concentration. The GC-MS conditions were as follows: Capillary column, Rxi-5ms, 30 m × 0.25 mm i.d. × 0.5 μm (Restek, Japan); temperature program, isothermal for 1 min at 50 °C, change from 50 °C to 250 °C at a rate of 15 °C/min, and isothermal for 5 min at 250 °C; injection volume, 1 μL; carrier gas, He; linear velocity, 5.19 cm/s; sampling rate, 1 s; MS mode, EI; detector voltage, 1.2 kV; interface temperature, 230 °C; ion source temperature, 200 °C.

Results and Discussion

After 7 days cultivation, all plate surface of light or dark condition were filled with *S. coelicolor* A3(2) mycelia. On the other hand, geosmin concentration in the plate was increased under light (white, blue, green, red) conditions compared with dark condition. Furthermore, geosmin concentration was gradually increased under blue and white light condition between 10 and 20 μmol m^{-2} s^{-1} light intensity. But the concentration tended to decrease above 20 μmol m^{-2} s^{-1}. These results strongly suggested that the lights played a key role in the induction of geosmin production activity by *S. coelicolor* A3(2). Especially short wavelength light such as blue influenced potently to producing geosmin by *S. coelicolor* A3(2). Also the production respondency might have threshold level of light intensity.

From the previous studies, carotenoid production of *S. coelicolor* A3(2) is induced by irradiating of blue light (2.4 μmol m^{-2} s^{-1}) but isn't induced when irradiated with red light (2.4 μmol m^{-2} s^{-1}) (Takano et al. 2005, Takano et al. 2006). In this study, on the other hand, geosmin was produced by *S. coelicolor* A3(2) under green and red light irradiation conditions. Because metabolic pathway of carotenoid and geosmin has different parts, we suggested that carotenoid and geosmin production could be affected by different factors under long wavelengths light irradiation. In conclusion, it was indicated that various wavelengths light irradiation would induce geosmin production of *S. coelicolor* A3(2).

Acknowledgements

This work was supported by Grant-in-Aid Scientific Research B (25281042) from Japan Society for the Promotion of Science (JSPS) and The Ministry of Education, Culture, Sports, Science and Technogy (MEXT).

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Antibacterial activity of lactobacilli against *Aeromonas veronii* isolated from Pichola lake, Udaipur, Rajasthan, India

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Keywords: *Aeromonas veronii*, Pichola lake, lactobacilli, antibacterial activity

Introduction

Water is the most basic and vital source of our planet. According to the UN (United Nations) reports, 1978 consumable water levels are up to 2.7% of the total water content (Belorkar, 2010). Water quality now is a concern for all countries in the world. One of the most important factors of water pollution is the microbial contamination especially with pathogenic organisms (Sabae et al., 2007). The pathogenic organisms include various types of bacteria, viruses and protozoans. They cause infection in humans as well as in aquatic animals. *Aeromonas* are commonly isolated from a variety of aquatic environments, including freshwater, estuarine, brackish, and salt waters. *Aeromonas veronii* is gram- negative, facultative anaerobic bacterium which causes disease in humans as well as aquatic animals (Coscon et al*.,* 1996). Lake Pichola, situated in Udaipur city is an artificial fresh water lake. It is polluted due to the disposal of sewage directly into the lake water.

In recent years, "Probiotics" defined as more precisely "mono or mixed cultures of live microorganisms which, when applied to animal, beneficially affect the host by improving the properties of the indigenous microflora". The term "Probiotic" inevitably refers to gram-positive bacteria associated with the genus *Lactobacillus* (Dhanasekaran et al., 2010). One of the requirements needed for probiotic strains is that they should possess antibacterial activity against various pathogenic organisms. Yasuda and Taga (1980) anticipated LAB would be useful both as food and as biological control agents of disease and activators of the rate of nutrient regeneration in aquaculture.

Hence the present work was carried out to screen the antibacterial activity of probiotic isolated from camel milk against water borne pathogen *Aeromonas veronii.*

Materials and methods

Isolation and morphological characterization of lactobacilli

For isolation of lactobacilli, serial dilution technique was used. Serial dilution was done using the saline solution. Decimal dilution of the samples was pour plated with the MRS medium. Colonies from MRS media plates of the highest dilution representing 10 colonies were picked and further purified by successive streaking for the isolation of *Lactobacillus*. Colonies picked were screened on the basis of Gram reaction, morphology and catalase test.

Screening of lactobacilli for antibacterial activity

For screening of antibacterial activity against *Aeromonas veronii*, lactobacilli were inoculated to MRS broth and incubated at 37^{0}C for 24-48 h. Cell-free culture supernatants (CFSs) of lactobacilli isolates were examined for their antibacterial activity by the agar well diffusion assay as described by Schillinger and Luke (1989).

Biochemical characterization of lactobacilli isolates

The isolates were tested for their ability to grow at different temperatures (15 and 45^{o}C) and their ability to produce CO_2 by the fermentation of glucose and NH3 production from arginine. Sugar fermentation patterns were determined using CHL (a basal media used for sugar fermentation test) as the basal medium.

Molecular characterization of the lactobacilli Isolates

The isolates were identified by 16S rRNA gene sequence analysis. The primers used for amplification of 16S rDNA region were Lb1 (5' AGAGTTTGATCATGGCTCAG- 3') and Lb2 (5'-CGGTATTAGCATCTGTTTCC-3') designed by klijn et al. (1993). Amplified PCR fragments was sequenced by Bangalore genei pvt. Ltd. The basic local alignment search tool (BLAST) was carried out with NCBI genebank database.

Results

A total of 10 isolates were recovered on MRS agar medium from camel milk sample. Among the 10 isolates only 2 isolates displayed the antibacterial activity against *Aeromonas veronii* which was isolated from Pichola lake, Udaipur and was previously identified. These two isolates were characterized screened on the basis of morphological and their biochemical reactions. The DNA of the two isolates was amplified by PCR using *Lactobacillus* genus-specific primers (Lb1 and Lb2). Both of the isolates gave specific band of 200bp confirming that they belong to genus *Lactobacillus*. Based on biochemical characters and sugar fermentation test, the isolates were tentatively designated as *Lb. Fermentum* CMU 31 and *Lb. rhamnosus* CMU 33. Sequence data obtained after partial sequencing of 16Sr DNA were analysed by BLAST. On the basis of similarity search (BLAST analysis), these isolates demonstrated high sequence similarity (99–100%) with existing Lactobacillus 16S rDNA sequence present in GenBank database, confirming isolate CMU 31 belong to *Lactobacillus fermentum* and isolate CMU 33 belong to *Lactobacillus rhamnosus.*

Discussion

The use of probiotics for removal of pathogenic bacteria in water is an research area of increasing interest. Probiotics have been defined by the World Health Organization – Food and Agriculture Organization, as "live microorganisms" which when administered in adequate amounts, confer a health benefit on the host. "In the past decade, several probiotic bacteria have been evaluated *in vitro* or *in vivo* for their potential to inhibit pathogenic organisms of water and overcome infections in humans, aquatic and terrestrial animals.

In the present study, 15 lactobacilli isolates were isolated from camel milk. These isolates were screened for antibacterial activity against *Aeromonas veronii*. Only 2 isolates gave the significant result. Similar work was carried out by *Dhanasekaran* et al. *(*2010) who have reported antibacterial activity of lactobacilli isolated from fish gut against *Aeromonas veronii*. The study concluded that these *Lactobacillus* isolates could be used as potential probiotics for aquaculture and will be helpful in the management of bacterial disease *Aeromonosis.*

Acknowledgement

The financial assistance received from University Grant Comission (UGC), New Delhi is gratefully acknowledged.

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The regularities of synthesis of low-molecular weight organic compounds by water macrophytes depending on biotic and abiotic factors

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Keywords: aquatic macrophytes, low molecular weight organic compounds, gas chromatography–mass spectrometry

Introduction

Low-molecular weight organic compounds (LMWOC) of aquatic macrophytes play a very important role in various processes in aquatic ecosystems and affect the composition and development of aquatic biocenoses. They can play important roles in intraspecific and interspecific interactions (Fink, 2007).

Without knowledge of the component composition of LMWOC of macrophytes (and other plants) and the regularities of its change under the influence of various factors it is impossible to talk about the development of the theory of the functioning of aquatic ecosystems and management practices of their development.

The aim of this work is to generalize own data on the component composition of LMWOC of aquatic macrophytes and show the dependence of their synthesis of some abiotic and biotic factors.

Materials and methods

The component composition of LMWOC was studied in the following macrophytes, growing in the Leningrad, Yaroslavl and Astrakhan regions of Russia: *Potamogeton natans* L., *P. perfoliatus* L., *P. lucens* L., *P. pectinatus* L., *P. pusillus* L., *Nitella syncarpa* (Thuill), *Lemna minor* L., *Nuphar lutea* (L.) Smith., *Ceratophyllum demersum* L.

Plants for analyses were sampled in diverse habitats with different combination of biotic and abiotic factors: in ponds, lakes and rivers.

Detection and identification of LMWOC were performed by gas chromatography-mass spectrometry in the programmed temperature mode with GC-MS complex TRACE DSQII (Thermo Scientific). The content of detected compounds were evaluated using internal standards (decafluorobenzophenone and benzophenone).

Results

Our study revealed that essential oil of aquatic macrophytes may contain a very large number of LMWOC: up to 38 in *P. natans*, up to 47 in *N. syncarpa*, up to 48 in *P. perfoliatus*, up to 70 in *P. lucens*, up to 85 in *P. pectinatus*, up to 97 in *L. minor*, up to 133 in *P. pusillus*, up to 139 in *N. lutea*, up to 236 in *C. demersum*.

Synthesis of secondary metabolites in macrophytes has a distinct seasonal dynamics as was shown by the example of *P. pusillus* and *C. demersum* (Kurashov et al., 2013, 2014).
Insolation provides an example of the influence of abiotic factors on the synthesis of the LMWOC by water plants. In particular, in shading (a shady pond with duckweed) essential oil of *C. demersum* contained 180 components, and in the absence of the shading - 121 LMWOC. Furthermore, mention should be made of significant differences in quantitative content of components between these two habitats. In shading conditions the concentrations of such compounds as manool (7.5 %) and β-cyclocitral (0.4 %) were higher than at a higher illumination level (0.4 and 0.2% respectively). At the same time, the content of diisobutyl phthalate (1.8 %), pentadecanal (1.6 %) and some other components has been significantly lower than at high insolation (4.4 and 11.1%, respectively).
Geographical (large-scale) differences in the production of LMWOC in the same phase of vegetation (flowering) may be illustrated by the example of *N. lutea* growing in three diverse reservoirs in Leningrad and Yaroslavl regions. The relative content and the concentrations of the most abundant compounds (> 1%) in essential oils of *N. lutea* presented in table 1.

Compound	**Kovats index**	**Mouth of River Volkhov**	**Lake Suuri**	**River Ild**
2-Hexanone	788	1.32 (0.00112)	1.71 (0.00154)	1.74 (0.0040)
Hexanal	796	1.05 (0.00089)	1.11 (0.00100)	-
Furan-2-carbaldehyde; [furfural]	820	1.23 (0.00104)	2.76 (0.00248)	-
(E)-Hex-2-enal	840	1.13 (0.00096)	-	-
2-Pentylfuran	987	-	1.82 (0.00164)	-
2-Methylhept-6-en-1-ol	994	1.41 (0.00119)	-	-
2-[(Z)-pent-2-enyl]furan	999	1.11 (0.00094)	1.01 (0.00091)	-
(E)-Non-2-enal	1155	-	1.01 (0.00091)	-
Pentadecanal	1713	-	8.20 (0.00737)	2.40 (0.0055)
Tetradecanoic acid	1777	-	2.12 (0.00191)	3.93 (0.0090)
6,10,14-Trimethylpentadecan-2-one	1845	-	-	3.27 (0.0074)
Bis(2-methylpropyl) benzene-1,2-dicarboxylate; [Diisobutyl phthalate]	1869	1.06 (0.00090)	2.32 (0.00208)	-
Pentadecanoic acid	1886	-	1.54 (0.00138)	-
(7Z,10Z,13Z)-Hexadeca-7,10,13-trienal	1890	-	1.21 (0.00109)	-
(5E,9E)-6,10,14-Trimethylpentadeca-5,9,13-trien-2-one; [Farnesylacetone]	1914	-	-	1.39 (0.0032)
Dibutyl benzene-1,2-dicarboxylate; [Dibutyl phthalate]	1961	2.13 (0.00180)	2.18 (0.00196)	3.17 (0.0072)
Hexadecanoic acid	1981	24.37 (0.02061)	19.24 (0.01730)	11.51 (0.0262)
(6E,10E)-3,7,11,15-Tetramethylhexadeca-1,6,10,14-tetraen-3-ol; [Geranyl linalool]	2027	-	1.14 (0.00103)	-

5-[(1S,4aS,8aS)-5,5,8a-Trimethyl-2-methylidene-3,4,4a,6,7, 8-hexahydro-1H-naphthalen-1-yl]-3-methylpent-1-en-3-ol; [Manool]	2044	2.21 (0.00187)	-	9.33 (0.0213)
Unidentified m/z 276 [M+], 207 (100)	2062	-	-	1.64 (0.0037)
(E,7R,11R)-3,7,11,15-Tetramethylhexadec-2-en-1-ol; [Phytol]	2113	13.25 (0.01121)	5.04 (0.00453)	28.83 (0.0657)
Methyl octadecanoate	2128	4.69 (0.00397)	3.44 (0.00309)	6.46 (0.0147)
(9Z,12Z)-Octadeca-9,12-dienoic acid; [Linoleic acid]	2153	28.74 (0.02431)	14.38 (0.01293)	5.82 (0.0133)
(9Z,12Z,15Z)-Octadeca-9,12,15-trienoic acid; [Linolenic acid]	2159	-	9.39 (0.00844)	-
Nonadeca-1,18-diene-7,10-dione	2175	-	2.20 (0.00198)	-
(6E,10E,14E,18E)-2,6,10,15,19,23-Hexamethyltetracosa-2,6,10,14,18,22-hexaene; [Squalene]	2821	-	-	1.57 (0.0036)
Total LMWOC (specific compounds among these)		104 (22)	112 (33)	99 (31)
Total concentration (mg/g DW)		0.08488	0.08990	0.22800

Table 1. Relative content (%) and the concentration (mg/g DW, in parentheses) of main compounds (> 1%) in essential oils of the *N. lutea* from different localities

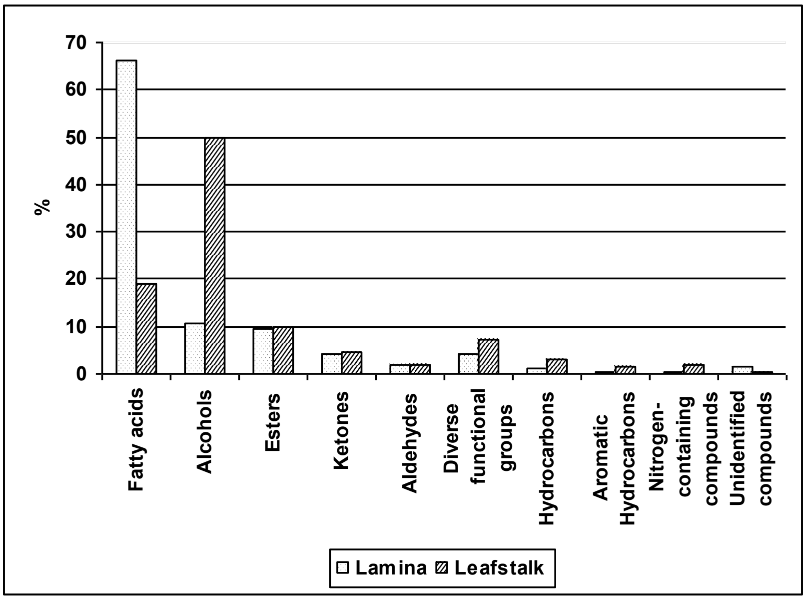

Fig. 1. Relative content (% in whole essential oil) of major groups of substances in the laminas and leafstalks of *N. lutea* in the beginning of vegetation (19/05/2010)

The largest number of LMWOC (112) was detected in essential oil of *N. lutea* from Lake Suuri. In a sample from River Volkhov it was found 104 compounds, and from River Ild - 99. The values of total concentration of LMWOC in samples from the mouth of the River Volkhov and Lake Suuri were very similar and amounted 0.08488 mg/g DW in sample from R. Volkhov and 0.08990 mg/g DW from Lake Suuri. At the same time, the total concentration of LMWOC in *N. lutea* from River Ild was significantly higher - 0.228 mg/g DW (table. 1). In all three samples of *N. lutea* following substances were significant fraction of the total amount of LMWOC: fatty acids (tetradecanoic, pentadecanoic, hexadecanoic, linoleic and linolenic); phthalates (dibutyl phthalate and diisobutyl phthalate) and phytol, a diterpene alcohol. Manool had significant values of abundance in samples from River Ild and River Volkhov. This compound was absent in *N. lutea* from Lake Suuri. A total of 48 compounds were common to the three samples studied, whereas many LMWOC were only found in any one sample: 22 components were specific to the sample of River Volhov, 33 - to Lake Suuri, 31 – to River Ild.

Various organs of macrophytes (e.g. *N. lutea*) may have different composition of LMWOC and different concentrations (Fig. 1).

The good protection of macrophytes would be afforded by LMWOC from their plant-eating invertebrates. In particular, higher concentration of phytol and presence of linoleic acid in the leaves of *N. lutea* (Fig. 2) prevent them from eating by *Galerucella nymphaeae* L., which is a typical consumer of *N. lutea* and *Nymphaea candida* J. et C. Presl. (Smirnov, 1960). It is also remarkable that the pentadecanal concentration was higher in undamaged laminas than in laminas consumed by invertebrates, 0.0047 mg/g DW and 0.0012 mg/g DW respectively. The decrease in the concentration of phytol and pentadecanal along with the termination of the synthesis of linoleic acid cause the leaves become available for herbivorous consumers.

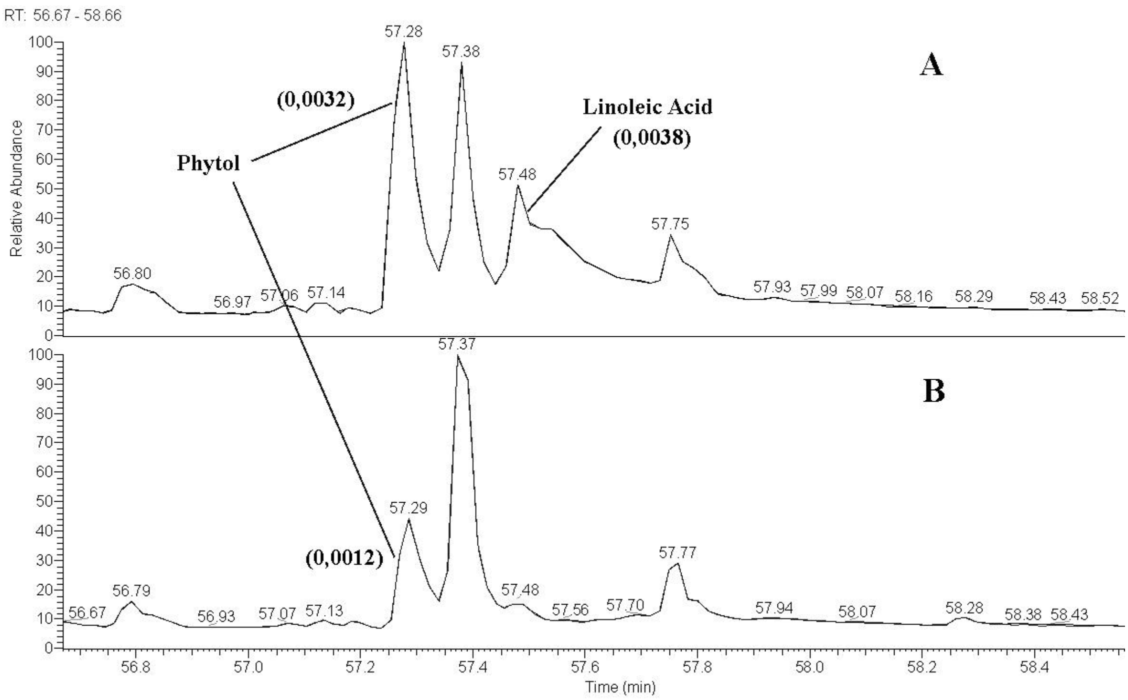

Fig. 2. Parts of the GC-MS chromatograms of essential oils of *N. lutea*: Differences in the content of linoleic acid and phytol in intact (A) and damaged by invertebrates (B) laminas of *N. lutea*. In brackets: the concentration of compounds, mg/g DW

Discussion

A large number of characteristic only for any studied habitats LMWOC of *N. lutea* shows the important role of environmental conditions in the formation of the spectrum of LMWOC synthesized by water macrophytes.

Habitat conditions are essential to the synthesis of LMWOC primarily due to the impact of the following factors: biological environment, geographical location, human impact. These factors largely determine the physico-chemical and hydrobiological conditions of growth of the plants. Special attention in future studies should be paid to the differences that may be caused by the anthropogenic factor. It is possible that certain LMWOC are synthesized in response to nutrient or toxic effects. In this case, they can be good markers for the identification of chronic adverse effects in the aquatic environment.
Disclosure of the specific functions of individual metabolites will help to understand the true mechanisms regulating many processes in aquatic ecosystems and the observed effects of transformation of aquatic communities and populations.

Acknowledgements
This research was supported by Sankt-Petersburg State University (Project № 18.38.85.2012).

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Analysis of physical, chemical and bacteriological parameters of Lake Pichhola in Udaipur District (Rajasthan), India

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Introduction

Water is an important natural resource. The presence of safe drinking water is an essential prerequisite for good health of society and for maintaining the natural and healthy aquatic ecosystem. The water quality is deteriorated due to pollution and it is the one of the major area of research for environmentalists. Industrialization, urbanisation and discharge from human activities result into organic enrichment. Due to this there is an undesirable change in physicochemical and biological characteristics of the water. The lakes of Udaipur are now increasingly being abused and severely polluted. Since lakes of Udaipur are the principal source of drinking water of the city, monitoring water quality of lake water is of significant value in combating the problems associated with public health due to organic pollution (Sharma *et al.*, 2008). Considering the above facts an attempt has been made to study the physicochemical and bacteriological parameters in order to ascertain the potability of water of lake Pichhola.

Material and Methods

Study Area: This is an old lake believed to be constructed by a Banjara at the end of 14th century which was later renovated in 1560 A.D. by Maharana Udai Singh. Lake Pichhola is situated between longitude 73^0 40'E and latitude $24^0$34'N and covers 6.96 km^2. The length of the lake is 3.6 km and maximum depth of the lake towards the Central Western part is 8 m. The maximum and mean width of the lake is 2.61 km and 1.93 km. respectively. The catchment area of the lake is 127 km^2.

Sample collection: The water samples were collected from three different regions of lake pichhola i.e. Gangaur ghat (Site I), Pichhola pal site (Site II), and Maaji ka mandir site (Site III). The water samples were collected during summer 2011, monsoon 2011, winter 2012, summer 2012, monsoon 2012 and winter 2013.

Analysis of physical and chemical parameters: For the purpose of estimating the physical and chemical properties of water, some selected parameters such as Temperature, pH, Dissolved oxygen, total alkalinity, total hardness, Biological Oxygen Demand (BOD), and Chemical Oxygen Demand (COD) were analyzed. The physicochemical estimations were done according to the methods given by APHA (1989), Pandey and Sharma (2003) and K.R. Aneja (2003).

Analysis of Bacteriological parameters: Bacteriological examination including total bacterial count and total coliforms of water samples were done by standard plate count method, multiple tube fermentation tests and membrane filtration method.

Results

Seasonal variations in physicochemical and bacteriological parameters of lake Pichhola during different seasons are given in Table 1.

Parameters	Summer 2011	Monsoon 2011	Winter 2012	Summer 2012	Monsoon 2012	Winter 2013	WHO permissible limit
Temperature (°C)	34	30.0	21.2	34.4	29.3	22.0	-
pH	8.69	7.80	8.00	8.70	7.94	8.04	6.5-8.5
Total Alkalinity	183	175	165	193	179	168	200 mg/l
Total Hardness	190	169	177	194	170	181	200 mg/l
DO (mg/l)	8.0	9.2	10.8	7.2	8.4	10.4	4 mg/l
BOD (mg/l)	3.73	4.0	5.3	2.8	3.73	4.8	3 mg/l
COD (mg/l)	25.6	27.7	32.0	21.9	23.5	30.9	10 mg/l
Total bacterial Count (cfu/ml)	39.0×10^3	75×10^3	34.3×10^3	49×10^3	81×10^3	36.0×10^3	<100/ml
Total Coliform count (by MPN method)	920	2400	340	1866.67	2400	376.67	<50/ml
Total Coliform Count (by Mem. Filt method)	736.67	2433.34	286.67	796.67	2533.34	313.34	<50/ml

Table 1. Average Values of Physicochemical and bacteriological Parameters of Lake Pichhola During Different Seasons

The values of average water temperature varied between 20.1 °C to 34.2 °C. Seasonal variation in average pH values were found in the range of 7.70-8.67. During the study, seasonal variation was observed in the values of total alkalinity, which was found in the range of 174- 196 mg/L. The average values of total hardness was found in the range of 171-200 mg/L and the average values of dissolved oxygen were varied between 7.3-10.0 mg/L. During the study period BOD was found in the range of 2.5- 4.9 mg/L and COD were found in the range of 20.8-31.5 mg/L.
The average values of standard plate count varied between $34.3\times10^3\ ml^{-1}$ to $81.0\times10^3\ ml^{-1}$. The average value of total coliform by multiple tube fermentation test and by membrane filtration method were ranged between 340/100 ml to 2400/100 ml and 286.67/100 ml to 2533.33/100 ml at the lake Pichhola.

Discussion

There was a notable fluctuation observed in the water temperature with respect to the season. In the present investigation, the values of pH indicated that the lake water was alkaline. WHO (World health organization) permissible limit for pH is 6.5-8.5. High values of pH during summer might be due to low level of water and concentration of nutrients in water and low pH values in monsoon were due to dilution caused by the rainwater during monsoon. WHO has set a desirable level of alkalinity in drinking water that is 200 mg/l. Therefore in the present study the values of summer 2012 were at the border line of the permissible limit. This is attributed to the routine washing and bathing activities conducted at the lake side.

Water hardness is a traditional measure of the capacity of water to precipitate soap. World Health Organization (WHO) has set a desirable level of total hardness in drinking water i.e 200 mg/l. Therefore in the present study the values of summer 2012 were at the border line of the permissible limit. Average values of DO of all the seasons were higher than the limits prescribed by WHO (4mg/l). The peak value during winter and lower value of DO in summer was also observed by Kadam et al. (2005), Kolekar, (2006), Negi et al. (2006), Pawar and Pulle (2005), Pulle et al. (2003), Sharma et al. (2008), and Upadhaya and Dwivedi, (2006). Pillai et al., (1999) found that total alkalinity has inverse correlation with dissolved oxygen which is similar to our findings. Biological oxygen Demand (BOD) is an important parameter to the oxygen required for degradation of organic matter. WHO has set a desirable tolerance limit for BOD which is 3 mg/l and the values found in present study were quite high than this limit indicating the high organic matter content in the lake water. The values of COD were quite high than the permissible limit of WHO (10 mg/l) indicating the pollution due to oxidisable organic matter.

Throughout the study period high level of coliforms were found. It is evident from the value 2400/100 ml during monsoon seasons for lake Pichhola. Sharma et al. (2008) also found the highest value of total coliform in monsoon season which is >2400/100 ml for lake Pichhola.

Acknowledgements

The first author is thankful to Council of Scientific and Industrial Research, New Delhi for providing financial assistance in the form of Junior Research fellowship and research support from the Department of Biotechnology, M.L.S. University, Udaipur for providing necessary laboratory facilities.

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Road de-icing salt and its effects on surface water: a case study in Northern Italy, subalpine Lake District

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Keywords: subalpine lakes, water chemistry, long-term trends, NaCl

Introduction

In the recent period, there has been a growing concern about the effects of increasing chloride concentration in surface waters, due to their potential damage to aquatic life. Increasing content of chloride has been observed in several lakes and rivers in urban areas or close to major roads in Europe and US (Müller & Gächter, 2012; Corsi et al., 2010). In Italy the use of sodium chloride (NaCl) as road de-icing agent is limited to northern regions and mountain areas. However, to our knowledge, possible effects of chloride on water quality have never been assessed.

Long-term series of chemical data exists, including major ions, for the lakes of the subalpine district in Italy. In this paper, we analyse trends affecting Cl and Na concentrations in the deep subalpine lakes during the last 25 years, with the aim to discuss the possible causes of temporal changes, with particular attention toward the use of NaCl as de-icing salt. The availability of data about chemical loads from the main tributaries makes possible to focus on the causes of the water chemistry trends in the case of Lake Maggiore.

Materials and methods

The deep subalpine lakes (DSL) (Maggiore, Lugano, Como, Iseo and Garda) constitute the most important water district in Italy, located south of the Alps, in one of the most densely inhabited and productive area of the country. They represent an essential and strategic water supply for agriculture, industry, fishing and drinking and are important resource for recreation and tourism. The surface of the drained area is 15536 km^2, i.e. about 20% of the watershed of the River Po, the largest and most important in Italy. The relevance of DSL is even higher in terms of water volume, which is 121 km^3, about 80% of the total freshwater volume in Italy, including artificial lakes.

Concentrations of major ions used throughout the manuscript are volume-weighted values obtained from 10-13 samplings at different depths along the water column. To compare the different lakes, data collected at the winter overturn (late February – early March) were used. We refer to Salmaso et al. (2007) and Salmaso & Mosello (2012) for further details on the lakes and analytical methods.

Results and discussion

The ionic balance of the lake waters, expressed as mean values of the periods 1988-1990 and 2010-2012, is shown in Tab. 1. Calcium, bicarbonate, sulfate and magnesium show the highest concentrations, followed by sodium and chloride, while potassium and nitrate show the lowest values. The comparison between the two periods puts in evidence an increase in total ion concentrations in all the lakes, ranging between 3.1% (Lake Lugano) and 6.8% (Lake Maggiore). Variations of measured electrical conductivity are in agreement with the increase in ion concentrations. Most of the increase, in absolute value, is due to Ca^{++} and HCO_3^- ions, followed by Na^+ and Cl^-. A slight decrease in sulfate concentration affected Lake Lugano, likely related to the decrease of sulfate input from atmospheric deposition in the area (Rogora et al., 2006). In the case of lakes Maggiore, Como and Iseo, a relevant contribution of sulfate from weathering is present, hiding the decrease due to atmospheric input. Although the increases of Na and Cl (Fig. 1) are lower in absolute value with respect to those of calcium and bicarbonate, their percent of increase is the highest among all ions, ranging from 10 to 32% in the case of Na and from 25 to 52% in the case of Cl.

		Maggiore		Lugano		Como		Iseo		Garda	
		1988-90	2010-12	1988-90	2010-12	1988-90	2010-12	1988-90	2010-12	1988-90	2010-12
Cond. 20°C	µS cm^{-1}	143	152	236	238	168	174	265	277	213	222
Ca^{++}	µeq L^{-1}	1061	1112	1824	1908	1240	1257	2146	2343	1637	1700
Mg^{++}	µeq L^{-1}	304	310	752	776	448	471	658	690	687	707
Na^+	µeq L^{-1}	100	132	109	124	123	141	121	133	150	179
K^+	µeq L^{-1}	38	39	34	31	36	35	29	33	25	28
HCO_3^-	µeq L^{-1}	756	832	2379	2466	1157	1237	1863	2046	2066	2193
Cl^-	µeq L^{-1}	55	82	63	83	64	81	70	87	128	159
SO_4^{--}	µeq L^{-1}	610	616	258	242	526	534	1043	1029	234	234
$N\text{-}NO_3^-$	µeq L^{-1}	56	60	14	14	60	60	58	51	23	26
Na^+	µeq L^{-1} y^{-1}	1.4		0.85		0.68		0.42		1.58	
Cl^-	µeq L^{-1} y^{-1}	1.21		1.01		0.71		0.84		1.47	

Tab. 1 Conductivity and major ion concentrations in the considered lakes in two different periods: 1988-90 and 2010-12. The yearly increase of Na and Cl concentrations in each lake is also shown

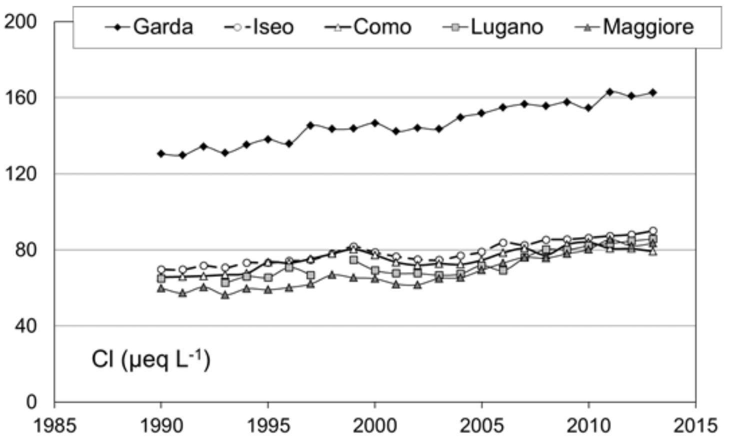

Fig. 1. Long-term trends of Cl^- concentrations in the DSL. Average values on the water column at winter overturn.

The Na:Cl ratio (on an equivalent basis) in the five lakes decreased in the considered period, as can be expected from an input of NaCl to lake water. In fact, in pristine conditions and in absence of mineral chloride in the watersheds, the main source of Cl to surface water is atmospheric deposition, where the Na:Cl ratio is close to 0.9-1.0, i.e. the value in sea spray.

On the other hand, sodium may be leached from silicate minerals. The resulting Na:Cl ratio higher than one should decrease in the case of further input of Na and Cl in 1:1 ratio.
The rate of increase over the whole period ranges between 0.7 and 1.5 µeq L^{-1} y^{-1} for Cl and between 0.4 and 1.6 µeq L^{-1} y^{-1} for Na and, in each lake, showed similar values for the two ions. Lake Garda shows the highest rate of increase (1.47 and 1.58 µeq L^{-1} y^{-1} for Cl and Na, respectively). This lake is also characterized by the highest absolute concentrations of the two ions, while the other four lakes show values in a very limited range. Again, the same rate of increase for the two ions is in agreement with the hypothesis that their main source is NaCl.
The causes of lake water chemical trends were investigated considering fourteen tributaries of Lake Maggiore, systematically sampled since 1978 to evaluate the algal nutrient and main ion loads to Lake Maggiore (Mosello et al., 2001). The total area drained by these tributaries is about 90% of the total lake watershed (6600 km^2). The total loads of Na^+ and Cl^- to Lake Maggiore increased respectively of 27 and 39% in the 35-year period. The increase in the case of Cl^- is more evident in the very recent years (from 2005), when Cl^- loads were steadily above 700 Meq y^{-1}.
An in-depth analysis was performed on monthly data of six tributaries (Cannobino, Toce, Ticino, Tresa, Maggia and Verzasca), draining together about 80% of the total area of Lake Maggiore watershed. Trends of Na^+ and Cl^- concentrations showed positive trends in all the rivers, with a more pronounced slope and peak values in winter and spring. Peaks of Na^+ and Cl^- mostly occur in the same samples, showing the dissolution of NaCl as the main cause.
The seasonality of these ion concentrations in the tributaries is reflected also in the upper lake water layer (0-20 m), where winter and early spring values are higher than the whole lake means.
We calculated the direct input of Na^+ and Cl^- to the lake surface via atmospheric deposition, using the data available for the station of Pallanza, located on the lake shore (Rogora et al., 2006): these inputs are very low with respect to those from the tributaries, clearly indicating the low importance of the atmospheric contribution to the total input to the lake.
The comparison between the increased loads of Na^+ and Cl^- and the amount of salt (mainly NaCl) used during the winter period for road de-icing showed a fair agreement. This aspect, together with the absence of other point source pollution for NaCl, permits to conclude that road de-icing is the main cause of the positive trends.

Conclusion

Present concentrations of Na and Cl in the DSL are fairly below the recommended limits for a good chemical status according to the Water Framework Directive and the observed increase of Na and Cl is still far to be potentially harmful for the biota or to affect water quality. However, considering the relevant volume of water of the DSL, these trends are indicative of an important chemical change occurring in the lakes, which warrants further. To address this problem in the proper way, the amount of NaCl used as de-icing agent in winter should be quantified and specific rules for its use adopted. Furthermore, ad-hoc studies in the lake catchments would be needed, to assess the eventual effects of road salt on soils, vegetation, and materials.

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Occurrence of perfluorooctane sulfonate (PFOS) and perfluorooctanoate (PFOA) in perch from Lake Varese (North Italy)

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Keywords: PFOS; perch, LC–MS/MS

Introduction

Perfluorooctanoic acid (PFOA) and perfluorooctane sulfonate (PFOS) are environmental contaminants belonging to a chemical group known as perfluorinated compounds. PFOS and PFOA are very persistent in the environment and bio accumulate in humans. The European Food Safety Authority (EFSA) recently pointed out that they are associated with adverse health effects. Diet is considered the main source of exposure to PFCs, which have been found more frequently in fish and other seafood, compared to other food groups. In fact, aquatic ecosystems represent the final reservoir for PFCs due to their great affinity for sedimentary and living organic matter. In these systems, measured levels of persistent organic pollutants (POPs) could increase along the trophic web, ultimately affecting humans that consume aquatic species. In this study, PFOS and PFOA was detected by LC-MS/MS in muscle samples of *Perca fluviatilis* from Lake Varese (North Italy).

Materials and methods

Sampling area.

Lake Varese is a smallish lake in the Lombardy region (North Italy) fed by underground springs. The lake is spread over an area of 14.5 square kilometers and has an average depth of 11 meters.

Study specie.

The European perch is a predatory freshwater fish species feeding on invertebrates and fish. Perch specimens were captured by gillnetting in 2012, in agreement with the animal welfare legislation procedure. Length ranged from 16.5 to 29.5 ± 0.5 cm and weight ranged from 53 – 371 ± 1 g. Fish were transported to the laboratory where samples were dissected to obtain muscle tissues.

Reagents and analytical method. Fish muscle (2.5 g) was homogenized with 2.5 mL of sodium hydroxide using Ultraturrax homogenizer (IKA, Staufen, Germany). The extract was purified and conditioned with 4 mL of methanol and 4 mL of water. The cartridge-purified extract was washed with 4 ml of 25 mM acetate buffer (pH 4-5), followed by 8 mL of methanol. Analytes were eluted with 1 mL of 2% ammonium hydroxide in methanol. The solvent was dried by evaporation by means of a nitrogen stream. The residue was reconstituted in the mobile phase and subjected to LC-MS/MS analysis, performed by an Agilent HPLC 1100 procedure (Agilent Technologies, Palo Alto, CA, USA). Mass spectral analyses were performed using an Applied Biosystems API 4000 triple quadruple mass spectrometer (Applied Biosystems Sciex, Ontario, Canada) operating in electrospray ionization (ESI) negative ion mode. Detection and quantification of the two molecules were performed by selected reaction monitoring (SRM), as shown in Table 1.

Analyte	Parent ion	Product Ion	Decluring potential (V)	Collision Energy (V)
PFOA	412.7	368.9 169.0 219.0	-61	-14 -26 -22
PFOS	498.5	80.1 99.0 169.0	-50	-94 -72 -51
Internal standard	420.7	376.0	-32	-14

Table 1. MS experimental condition of PFOA and PFOS and internal standard

The method limit of quantification (LOQ) was 0.50 ng g^{-1} for PFOA and 0.70 ng g^{-1} for PFOS, with a recovery rate of 99-102% and 96-108%, respectively.

Results

PFOA was not found in any of the investigated samples above the limit of quantitation of 0.50 ng g^{-1} fresh weight (fw), whereas PFOS was detected in all samples with concentrations ranging from 5.4 to 17.2 ng g^{-1} fw (mean 9.6 ng g^{-1} fw). The Scientific Panel on Contaminants in the Food Chain (CONTAM) set a provisional TDI of 150 ng kg^{-1} b.w. per day (EFSA, 2008). In an adult consumer with a body weight of 60 kg, this value is reached consuming fish that contains 30 ng g^{-1} of PFOS, considering a consumption of 300 g fish per day. We estimated human exposure from fish consumption by calculating the Estimated Human Daily Intake (EHDI), as follows: EHDI = (C X DC)/BW, where C is the contaminant mean concentration, DC indicates the daily fish consumption for the Italian population, as reported by the National Research Institute for Food and Nutrition (Leclercq et al., 2009), and BW is the human body weight (60 kg). The consumption figures used were the 50th and 95th percentile intakes for the total population in consumers of all ages; we obtained EHDI values of 5.15 ng kg^{-1} bw day and 23.55 ng kg^{-1} bw day.

Discussion

PFCs concentrations are usually higher in fish caught from fresh water compared to fish from open oceans (Berger et al., 2009). In the 2011 EFSA Opinion a constantly higher mean PCFs concentration in fish from fresh water was demonstrated. Among PFCs, PFOS had the highest mean concentrations that in fish meat ranged from 0.04 to 211 ng g^{-1}. In the present study, PFOS mean values were 9.6 ng g^{-1} fw in *Perca fluviatilis*, while PFOA values were less than the limit of quantitation in all samples. This is the first study that document the presence of PFCs in Lake Varese. Once in the environment PCFs are extremely persistent and don’t undergo significant further abiotic or biotic degradation. However, PFOS exhibits a higher tendency to bind to organic matter and bio accumulate compared to PFOA, due to its longer perfluoroalkyl chain length (Conder et al. 2010). Monitoring data from top predators at various locations show highly elevated levels of PFOS and demonstrate the substantial bioaccumulation and bio magnification properties of PFOS (Bossi et al., 2005a,b). Consumption of fish and fishery products is known to be a source of exposure to PFOS, PFOA, and other PFCs (Nania et al., 2009). Several studies indicated that PFOS and PFOA are present in the environment, including within the human body (EFSA 2012). Adverse health effects, e.g. hepatotoxicity, developmental toxicity, neurobehavioral toxicity, reproductive toxicity, hormonal effects, as well as a weak genotoxic and carcinogenic potential have been demonstrated in experimental studies in animals (Zhang et al., 2009; Pinkas et al., 2010). Comparing our EHDI with the TDI established for PFOS we can conclude that the intake related to fish consumption from Lake Varese is well below the tolerable daily intake (TDI). Even if our results did not show a particularly alarming level of pollution by PFCs, other food and sources other than food may contribute to the total human exposure. Particularly for high fish consumers the intake from fish may constitute a considerable contribute to the TDI of PFOS. Then, measures should be taken to reduce the consumption of these damaging substances by humans.

Acknowledgements
This work was financially supported by the Italian Ministry of Health.
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Application of Water Quality Model for Selection of River-flow Pattern and Location for Pollution Disposal in a Large Reservoir

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Keywords: water quality model, river, reservoir, pollution

Introduction

Water quality processes in a reservoir are dependent on river flow conditions and physiography of a reservoir. The river flow affects the concentration and distribution of water quality variables in the reservoir. Rapid transport of pollutants by high flows results in a short residence time and often causes minimal water quality problem. Conversely, slow transport of pollutants by low flows results in a longer residence time and can lead to water quality problems, such as oxygen depletion and eutrophication (Ji, 2008). In the present study, three zones within a large reservoir, namely Riverine, Transition and Lacustrine were studied for their suitability for placing a location of Pollution disposal, under three different patterns of the main river-flow namely Constant, Cyclic flow 1 (increasing trend), Cyclic flow 2 (decreasing trend). Keeping the total discharge same in all three cases, simulations were run for one month using MIKE 21 software. Water quality models are extensively used to predict spatial variation in water quality (Palmer, 2001). Pollution load was given as Biochemical Oxygen Demand (BOD) in 5 different concentrations ranging from 30-700 mg/l, keeping Dissolved Oxygen (DO) constant (6 mg/l). Water quality of outflow water was assessed through variations in BOD and DO.

Water quality indices are intended to provide a simple and understandable tool for managers and decision makers on the quality and possible uses of water body (Bordalo, 2001; Gatot & Rina, 2011). Water Quality Weightage(WQW) method used in the present study gives an overall quick idea about how the different flow patterns result into the different water quality scenarios and choose the best one for the water quality management.

Materials and methods

The model was prepared for 50 km long part of reservoir on dam-side with rectangular grid of 390m X 50m in X and Y directions respectively. The upstream most end of the model was an open boundary for simulating the river discharge into the model area, as observed at site. One closed boundary near dam, on right bank, was provided to simulate the withdrawals from the dam. Reservoir levels as observed daily at the dam were simulated at this closed boundary. Including the hydraulic effect of ambient flows from six locations from the right bank and five locations from the left bank and the evaporation, precipitation and wind forcings, the model was calibrated and verified with the field-observed data of flows and water quality (Prabhakar & Vaidya, 2011).

With the verified model, the predictive runs for one month duration were taken for the typical non-monsoon scenario, where three points of incoming pollution were placed in the riverine zone, transition zone and lacustrine zone, of model, to observe respective scenario of water quality distribution in the reservoir. The maximum BOD load of 700mg/l was equally distributed over three points. The total load matched prevailing organic loads generated by some mega cities elsewhere, with the prevailing efficiency of treatment mechanisms. In the cosequent runs the load was gradually softened from 700 to 30 mg/l BOD to achieve the resultant water quality that will meet the class A criteria as per CPCB (1992) (BOD<2mg/l and DO>6mg/l).

In all the cases the concentration of DO and nitrate in the polluting discharge was taken zero and that of ammonium and phosphate was taken as 5mg/l. Simulation was carried out with cyclic 1 (Cyc 1), Cyclic 2 (Cyc 2) and constant (Con) discharge-patterns of the ambient flows from up-stream boundary. Five different pollution loads (as BOD 700, 400, 200,100 and 30 mg/l) at the rate 6m^3/s were distributed into 3 points, all the 3 points placed in same zone at a time.

For assessing the results of number of experimental runs, Water Quality Weightage (WQW) Method is formulated. It is like calculating the Water Quality Index (WQI) which provides a single number (like a grade) that expresses overall water quality at a certain location and time, based on several water quality parameters. This provides a simple and understandable tool for managers and decision makers on the quality and possible uses of water body. From the result file, the average quality of water in the near-dam zone, with respect to BOD, DO, N and P was cosidered as the resultant quality of water which will be used by neary locality.

Thus 5 runs each, with placement of pollution sources in three zones, under three discharge patterns were taken. Thus total 45 case results were compared by designating the water quality weightage (WQW). This study helps to identify the discharge pattern of choice for disposal of pollutant for better management of reservoir water quality.

Results

Results for simulation with pollution from Lacustrine zone (LZ), Transition Zone (TZ) and Riverine Zone (RZ) are presented in Table 1, 2 and 3 respectively. Average BOD and DO in the near-dam region is indicated for three discharge patterns wth 5 different pollution loads. The corresponding classes (CPCB) are then assigned.

Pol Load mg/l BOD	Resultant BOD and DO mg/l						Corresponding Classes (CPCB)					
	BOD			DO			BOD			DO		
	Con dis	Cyc dis1	Cyc dis2	Con dis	Cyc dis1	Cyc dis2	Cyc dis	Cyc dis1	Cyc dis2	Con dis	Cyc dis1	Cyc dis2
30	0.69	0.74	0.70	6.19	6.39	6.00	A	A	A	A	A	A
100	1.39	1.39	1.53	5.91	6.12	5.61	A	A	A	B	A	B
200	2.40	2.32	2.74	5.52	5.75	5.08	B	B	B	B	B	B
400	4.45	4.21	5.23	4.78	5.04	4.12	D	D	D	D	B	D
700	7.62	7.13	9.18	3.81	4.08	2.95	E	E	E	E	D	E
Total WQW (A=4;B=3;C=2;D=1;E=0)							12	12	12	11	15	11

Table 1. Resultant BOD, DO and the corresponding class (Five different Pollution loads given from Lacustrine zone)

Pol Load mg/l BOD	Resultant BOD and DO mg/l						Corresponding Classes (CPCB)					
	BOD			DO			BOD			DO		
	Con dis	Cyc dis1	Cyc dis2	Condis	Cyc dis1	Cyc dis2	Cyc dis	Cyc dis1	Cyc dis2	Con dis	Cyc dis1	Cyc dis2
30	0.59	0.62	0.52	6.10	6.35	6.02	A	A	A	A	A	A
100	1.04	0.98	0.90	5.63	6.00	5.54	A	A	A	B	A	B
200	1.71	1.50	1.46	5.00	5.52	4.89	A	A	A	B	B	C
400	3.16	2.59	2.71	3.86	4.63	3.75	E	C	C	E	C	E
700	5.54	4.36	4.88	2.53	3.48	2.43	E	E	E	E	E	E
Total WQW (A=4;B=3;C=2;D=1;E=0)						12	14	14	10	13	9	12

Table 2. Resultant BOD, DO and the corresponding class (Five different Pollution loads given from Transition zone)

Pol Load mg/l BOD	Resultant BOD and DO mg/l						Corresponding Classes (CPCB)					
	BOD			DO			BOD			DO		
	Con dis	Cyc dis1	Cyc dis2	Con dis	Cyc dis1	Cyc dis2	Cyc dis	Cyc dis1	Cyc dis2	Con dis	Cyc dis1	Cyc dis2
30	0.55	0.60	0.45	6.11	6.33	6.10	A	A	A	A	A	A
100	0.89	0.91	0.69	5.61	5.92	5.86	A	A	A	B	B	B
200	1.14	1.38	1.02	4.93	5.36	5.17	A	A	A	C	B	B
400	2.56	2.97	1.76	3.74	4.35	4.20	C	C	A	E	C	C
700	4.62	4.10	3.06	2.39	3.07	3.00	E	E	E	E	E	E
Total WQW (A=4;B=3;C=2;D=1;E=0)						14	14	16	9	12	12	14

Table 3. Resultant BOD, DO and the corresponding class (Five different Pollution loads given from Riverine zone)

Discussion

The different water quality scenarios are evaluated numerically by the assigned weightages. After assigning the WQW, the scores are calculated in the last row of the tables.

The WQW results show that with overall quality criteria of BOD and DO, the Cyclic discharge pattern resulted in higher score than the constant discharge pattern, irrespective of the zone of placement of pollution sources. This may be due to better advection and dispersion conditions caused by cyclic flow variation. These processes are known to enhance the assimilative capability by increased rate of DO-mixing and re-aeration within the river/reservoir. However, considering the overall scores the placement of pollution sources in the order of preference were found to be Lacustrine, Transition and Riverine zone.

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Assessment of a battery of biotests for assessing the genotoxic potential of environmental pollutants

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Keywords: *Sinanodonta woodiana*, *Unio pictorum, micronucleus test, genotoxicity*

Introduction

Industrial and communal wastewaters transfer high concentrations of heavy metals, organic compounds and systematic chemicals into the environment. These pollutants damage fresh water organisms and through drinking water and bioaccumulation in the food chain may effect humans so biomonitoring of water pollutants is essential.

Bivalves are ideal test organisms for toxicological testing of water borne pollutants: they are sedentary creatures, being exposed to both water and sediment contamination and represent the two most common exposure routes of environmental pollutants. Furthermore their ability to bioaccumulate and bioactivate chemicals is also well established (Ponta et al. 2002) and they are widely used in biomonitoring (e.g. Jha et al. 2000 and Kolarevic et al. 2011.

The micronucleus (MN) test is a well known method in toxicity testing where MN formation indicates mitotic chromosome breakage or chromosome mis-segregation (Bolognesi et al. 2012). Several studies use the mussel MN test (Bolognesi et al. 2012, Scarpato et al. 1990). According to these studies sensitivity of this bioassay is sufficient to detect genotoxic components in environmental monitoring (Bolognesi et al. 2012).

Freshwater mussel populations are decreasing all around the world in response to water pollution, and the number of endangered mussel species increases. As such, native species of mussels should be replaced by exotic species in toxicological testing, but because these species are usually more resistant to environmental stress than native ones, the sensitivity of potential test species should be compared.

In our study, the genotoxic potential of two well known pollutants with high relevance in fresh water pollution, Copper(II)sulfate ($CuSO_4$) and benzo(a)pyrene (B[a]P) was evaluated using the MN test and the bacterial bioassays. MN test was conducted on two Unionid species, the native *Unio pictorum* and the invasive *Sinanodonta woodiana*, in this way their sensitivity could also be compared.

Materials and methods

Mussel specimens were exposed to a single administration of sub-lethal doses of $CuSO_4$ (Fig 1.) and benzpyrene (B[a]P) in 0.07% acetonitrile (Fig 2). After 4 days of exposure haemolymph was taken and samples were fixed according to Woznicki et al. (2004). The number of MN in 250 agranular haemolimph cells was detected (Zeiss AxioScopeA1, AxioCam ICC1, Zen 2011). Concentration-response curves of chemicals were defined, effect of chemicals was evaluated by one-way ANOVA and Tukey post hoc test. The sensitivities of the mussel species were compared with two way factorial ANOVA.

For the SOS-Chromotest the SOS-Chromotest TM kit (Environmental Bio-detection Products Inc.) was used according to the manufacturer's instructions. Induction factor (IF) was calculated according to Krifaton (2012).

The fluctuation Ames test was performed according to Hubbard et al. (1984), and χ2 test was applied with 95 % confidence level for the evaluation of mutagenic effect.

Results

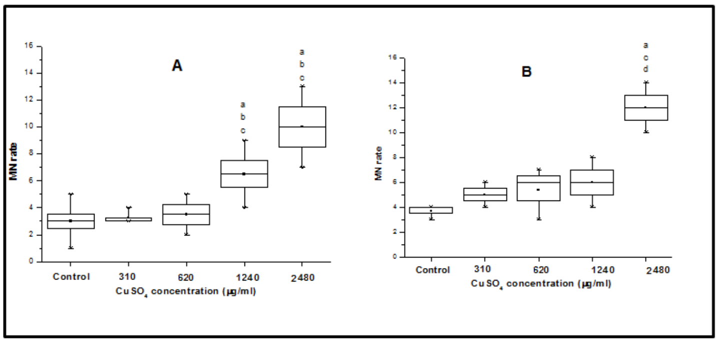

Fig. 1. Result of the MN test of *U. pictorum* (A) and *S. woodiana* (B) with $CuSO_4$ (significant difference compared to control (a), to 310μg/ml (b) to 620μg/l B[a]P (c) to 1240μg/l and to 2480μg/l (d))

Significant differences in MN numbers between the control and each concentration of the chemicals were observed in both *S. woodiana* and *U. pictorum* for $CuSO_4$ (ANOVA: F=11.953; df= 4 p<0,001 and F=16.392; df=4 p<0,00 01 respectively) and for B[a]P (ANOVA: F=6.465; df=3; p=0,007 F=12.015; df=5; P<0.00001 respectively).

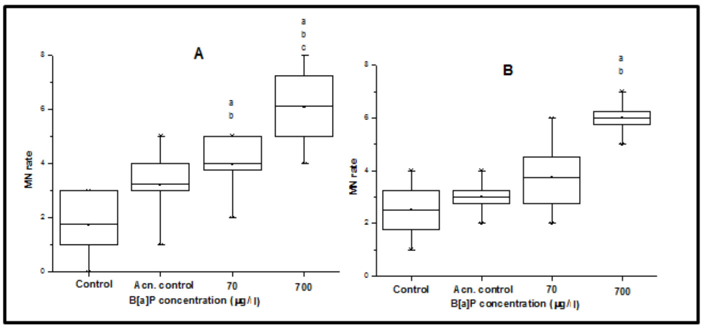

Fig. 2. Result of the MN test of *U. pictorum* (A) and *S. woodiana* (B) with B[a]P (significant difference compared to control (a), to Acn. control (b) and to 70μg/l B[a]P (c))

According to the Tukey post hoc test, variations between the micronuclei formation inducing effect of $CuSO_4$ and B[a]P occur between the two species (Fig 1.-2.). Results were compared by two way factorial ANOVA (concentrations and species were defined as independent variables, and MN number as dependent variable) with Greenhouse-Geisser correction: mean effect of concentration (F=16.243 df=1.168 p=0.043) and species x concentration interaction (F=12.721 df=1.4 p=0.041) were revealed. The results of Ames fluctuation test is indicated at Table 1.

$CuSO_4$ Concentration (µg/l)	0	310	620	1240	2480
Percent of positive wells	21.5±7.7	17.0±1.4	28.0±0.0	29.0±0	31.5±0.7
χ^2		0.043*	0.337	0.087	0.11
B[a]P Concentration (µg/l)	0	70	175	350	700
Percent of positive wells	5.0 ± 0	13.0±1.4	15± 1.4	15.5±2.1	20.5± 2.2
χ^2		0.017*	0.004*	0.003*	$4.1*10^{-5}$*

Table 1. The results of Ames fluctuation test (significant differences are marked by *)

In case of B[a]P SOS-Chromotest gave postitive results at 70µg/l, but in case of $CuSO_4$ IF values were under 1.5, so genotoxic effect was not detected even in the highest concentrations.

Discussion

Although the micronucleus test is a widely used mutagenicity test, relatively few comparative studies exist in case of the application to freshwater species. According to our knowledge there are only two studies comparing MN test to bacterial tests: Mouchet et al. (2006) and Eck-Varanka et al. (2014).

In our study the sensitivity of *S. woodiana* to $CuSO_4$ and B[a]P was compared to that of the fluctuation Ames test and SOS-Chromotest, and for the first time the sensitivity of two mussel species in response to these chemicals was compared to each other.

Both species responded to $CuSO_4$ and B[a]P with sufficient sensitivity, so the MN test is adequate to detect these contaminants in biologically relevant concentrations.

The results of the factorial ANOVA revealed that the sensitivity of the two mussel species was similar in case of both chemicals. The MN frequency was mainly affected by the concentration of chemicals, but in case of $CuSO_4$ species-concentration interaction had also significant effect. The sensitivity of *S. woodiana* is comparable to the sensitivity of *U. pictorum*, so at least for the studied chemicals, the invasive *S. woodiana* can be a good surrogate species in toxicological monitoring.

In the fluctuation Ames test the lowest studied concentration of B[a]P induced reverse mutations with S9 activation, and $CuSO_4$ induced mutagenicity in the 310µg/l concentration. Higher concentrations of $CuSO_4$ were cytotoxic for test bacteria, and no cell proliferation was observed. The SOS-Chromotest indicated no genotoxic response in case of $CuSO_4$, but 70µg/l concentration of B[a]P induced SOS-response.

Our results, in concordance with other works, indicate that the sensitivity of SOS-Chromotest may not be sufficient enough to detect genotoxicity, and is lower than the sensitivity of the fluctuation Ames test. The sensitivities of mussel micronucleus test and fluctuation Ames test - even though they apply very different endpoints, test organisms and effect modes - were very similar to each other. For samples with unknown composition and for environmental monitoring the application of both tests can be advised.

Acknowledgements

This work was supported by the TÁMOP-4.2.2.A-11/1/KONV-2012-0064 research program. This project is supported by the European Union and co-financed by the European Social Fund.

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Temporal and spatial variations in settlement and shell growth of *Limnoperna fortunei* (Dunker, 1857) (Bivalvia: Mytilidae) in a small lake of south Thailand

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Keywords: Thailand, *Limnoperna*, settlement patterns, population parameters, lake

Introduction

Limnoperna fortunei (Dunker, 1857) are native to China and Southeast Asia. *L. fortunei* were introduced to Hong Kong, Japan and invaded Argentina, and extended to other countries on the American continent (Ricciardi, 1998; Belz et al., 2010). Because of their potential successful invading ability and wide environmental tolerance, a number of biological studies have been conducted in the temperate and subtropical invasive ranges (Ricciardi, 1998; Spaccesi, 2013).
The present study aimed to validate temporal and spatial variations in settlement and to estimate growth parameters of *L. fortunei* in a tropical lake within their native range.

Materials and methods

The study lake was a small permanent dam reservoir on a karst formation, located at 8°58′01″N, 98°48′59″E, in a forest park of the Plant Genetic Protection Area, Rajjaprabha Reservoir, Surat Thani Province, south Thailand. Maximum length of the lake was 255 m, width 36–65 m, and maximum depth 3.5 m. The substratum is bedrock, with sparse cobble, gravel, and muddy sand. Water input originates from rainfall and seepage. The two major climatic seasons are the rainy and intermediate dry seasons. A small rainy season occurs during the southwest monsoon (May–September), a proper rainy season occurs during the northeast monsoon (October–January), and the intermediate dry season occurs between February and April. Surface water temperatures vary between 24.5°C in December and 34°C in May.
Three sampling stations were set in the lake to distinguish temporal and spatial variations in settlement of *L. fortunei*. Two sampling sites were randomly placed at each station, and surface and bottom levels were laid. Two 10 × 10 cm^2 multi-purposed scouring pads were soaked in the lake for a month per level at each site, and the pads were replaced the next month. The collecting panels were brought back to the laboratory, examined, and counted under a stereomicroscope for the numbers of *L. fortunei* spat <2.0 mm. The counts were recorded according to station, site, level, and replicate. While gathering the collecting panels, on-site measurements of water level, air and water temperatures, pH, conductivity, hardness, and transparency were conducted. The settlement density of *L. fortunei* on the scouring pads was verified using ANOVA.
Live *L. fortunei* were scraped from their natural populations between June 2010 and May 2012. Shell length was measured to the nearest 0.1 mm using a digital caliper. Length-frequency distributions were plotted at 0.5-mm intervals, and Bhattacharya's method was used to identify the age groups. Identifiable cohorts, based on the identified age group trend

and standard deviation, were selected and fitted to an appropriate growth equation, asymptotic length (L_∞), and growth coefficient (K).

Results

Limnoperna fortunei spat occurred all year round (Fig. 1A). The average number of spat on the collecting panels during 2011–2012 was significantly higher than that during 2010–2011. The average settlement during the northeast monsoon was significantly higher than that during the southwest monsoon and the southeasterly winds (Fig. 1B). The settlement density was significantly different among stations. The average settlement density on the bottom panels was higher than that on the subsurface (Fig. 1C). The average settlement density during the northeast and southwest monsoons was significantly higher during 2011–2012 than during 2010–2011 (Fig. 1D). A positive correlation was observed between the settlement density and water conductivity (Fig. 1E), but no correlation was observed with water level, temperature, pH, hardness, or transparency.

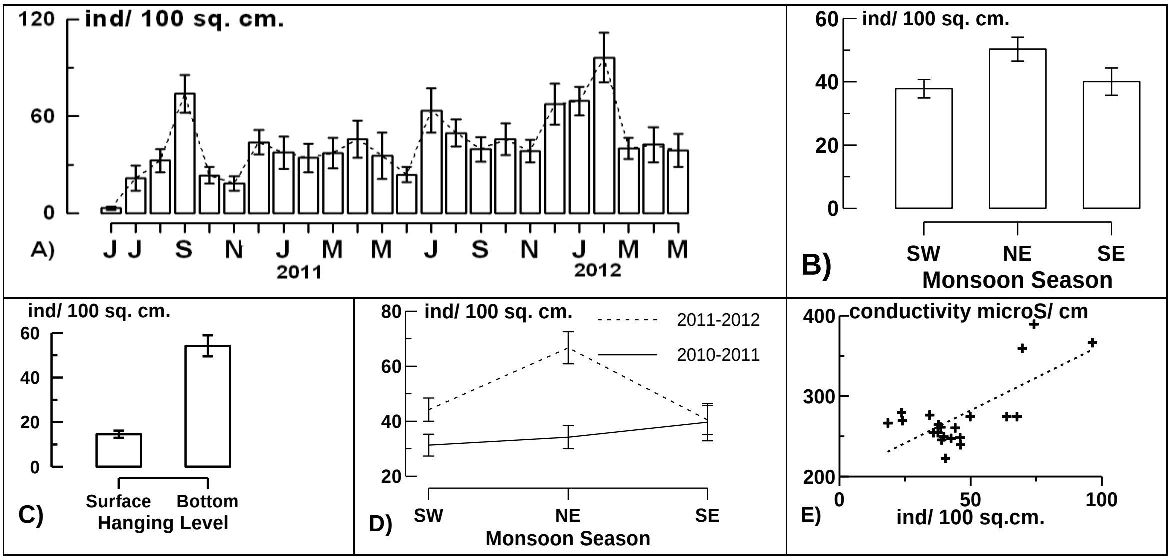

Fig. 1. Temporal and spatial variations in the settlement of *Limnoperna fortunei* (Dunker, 1857) in a small lake of south Thailand. A) Mean ± 1 SE of the settlements between June 2010 and May 2012, B) Overall mean ± 1 SE of the settlements for each season between June 2010 and May 2012, C) Mean ± 1 SE of the settlements for the surface and bottom collecting panels, D) Mean ± 1 SE of the settlements for each season of 2010–2011 and 2011–2012, and E) Positive correlation between settlement number and water conductivity. (SW= Southwest, NE= Northeast, SE= Southeast)

The length frequency of *L. fortunei* showed a clear polymodality (Fig. 2A). More than 130 age groups were identified. Mean shell length of the identified age groups for each sampling month with possible link modes for 5 selected cohorts is given in Fig. 2B. Overall selected cohorts conformed to a logistic regression rather than the von Bertalanffy growth function (VBGF) (Fig. 2C). No significant differences were observed among selected cohorts. The population parameters estimated on the basis of logistic regression exhibited a high K value of 2.483 yr^{-1} and a L_∞ value at of 22.02 mm with an estimated life span of 2.5–3.0 yr. Subsequently, estimated lengths at age (L_t) were anticipated and calculated for the appropriate growth models:

$$L_t = 22.02/[1 + 7.24\, e^{(-2.483x)}]$$

A major peak in recruitment occurred in March and May, and a minor peak occurred between July and October (Fig. 2E).

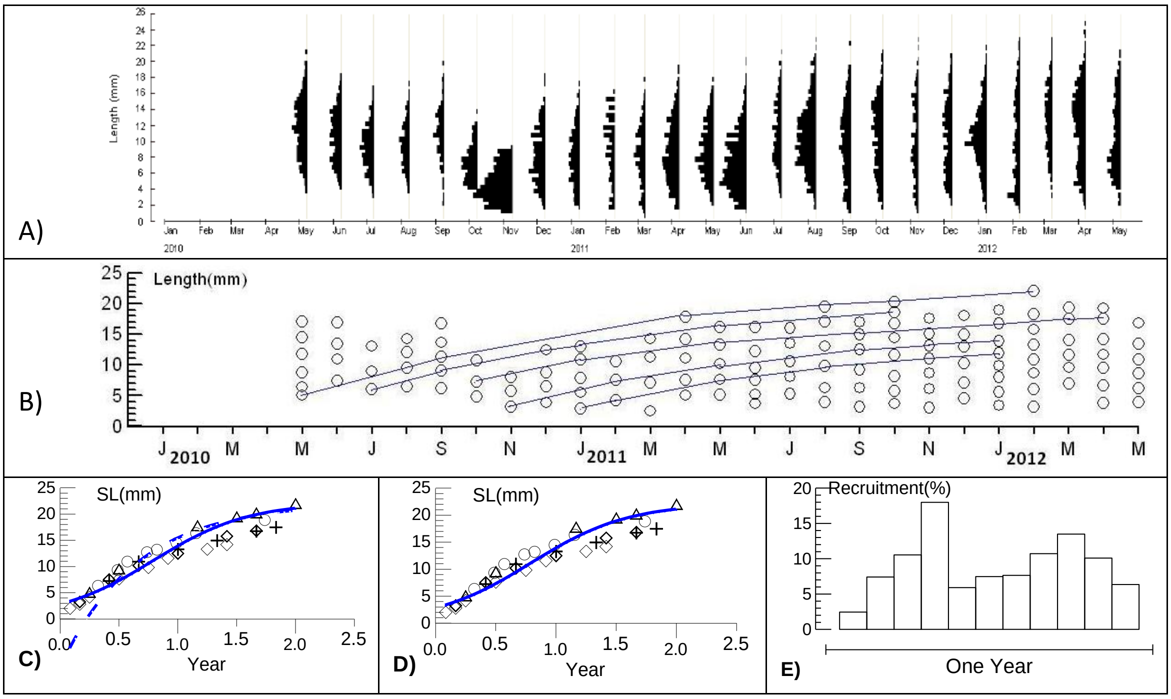

Fig. 2. Length frequency analysis of *Limnoperna fortunei* (Dunker, 1857) obtained from a small lake of south Thailand during 2010–2012. A) Monthly length-frequency distributions, B) Mean shell length of the identified age groups and growth trend of 5 selected cohorts, C) Growth curve fit: Logistic growth regression (solid line) vs. von Bertalanffy growth function (dash line), D) Logistic growth curves for 5 selected cohorts, and E) Recruitment pattern

Discussion

We found that *L. fortunei* reproduces all year round (Figs. 1A and 2E), and settlement during both peaks was strongly linked to environmental and climatic factors. Darrigran et al. (1999) found veliger larvae when the water temperature rose above 20 °C. The water temperature in our study lake fluctuated above 20 °C all year round and was well above the lower temperature limit for larval development (Ricciardi, 1998). This may have led to continuous reproduction throughout the year. Ricciardi (1998) suggested that 30 °C is the upper temperature limit, which resulted in larval mortality and early settlement, and may have been the reason why settlement dropped between March and May of 2011 and of 2012 and probably other months. A similar phenomenon was observed by Montalto and Marchese (2003).

Significant differences in the settlement were observed among seasons and between study years (Fig. 1B and 1D). This variability probably varied every year and every season because of adaptive and reproductive variations in adults in the heterogeneous habitats of each station even within the same lake or same river, as suggested by Iwasaki and Uryu (1998). A significant difference among stations was detected, suggesting that the spatial range of settlement was heterogeneous and indicating that within-lake dispersal of larvae was high. Higher settlement at deeper levels (Fig. 1C) was probably related to larval behavior such as predation avoidance in the planktonic stage or phototaxis prior to settlement.

A significant correlation was observed between the settlement and water conductivity (Fig. 1E). Spaccesi (2013) demonstrated a significant relationship between abundance of recruits and the combination of temperature and physicochemical variables, including water conductivity. This result indicates that a single environmental variable is not sufficient to explain the larval settlement. The fluctuation in water conductivity was possibly related to Ca^{2+} weathering from karst, which can regulate the presence, survival, and density of the recruits via shell formation.

L_∞ of *L. fortunei* in the present study was 22.02 mm, which was smaller than that in previous reports, whereas *K* exhibited a considerably higher value of 2.453 yr^{-1} than that reported from a temperate area. We found that the *L. fortunei* growth pattern conformed to logistic growth rather than VBGF as mentioned in most reports (Fig. 2D). According to our results, *L. fortunei* had a growth rate greater than that reported previously, suggesting that differences in growth could be associated with climatological conditions. The greater growth rate in the present study can be explained by the longer growth period.

Acknowledgment

The study was supported by the grant **SCI530118S** to the authors from Prince of Songkla University.

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A first application of the new assessment method for Italian lakes, EPI-L, in Mediterranean ecoregion

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Keywords: phytobenthos, Mediterranean lakes, reservoirs, Index EPI_L, Water Framework Directive

Introduction

Aquatic ecosystems protection, and particularly the understanding of the causes of anthropogenic environmental alteration of the same, are taking an important role in the last years. According to the Water Framework Directive 2000/60/EC (WFD; European Union, 2000) the Member States of the European Union are obliged to assess the ecological status of waters through biological quality element and as supporting these, the physical and chemical properties of the water bodies are to be use as well as the hydromorphological parameters of the lakes. According to WFD, for each biological quality elements, five status classes (high, good, moderate, poor, bad) are identified to assess ecological status. For each type are defined reference conditions and degradation is described from the deviation in species composition and abundance from those present at reference conditions (Ecological Quality Report: EQR). Diatoms are an abundant and important component of algal assemblages in freshwater lakes. These are used as indicators for the assessment of environmental conditions according to the WFD. The aim of this study is the first Italian application of the new index for ecological quality assessment of lake waterbodies using benthic diatoms “The Italian method for evaluating lake ecological quality from benthic diatoms (EPI-L)”(Marchetto *et al*, 2013) and to evaluate its response to different diatom assemblages. The EPLI-L was studied in relation to lake ecosystems in Mediterranean ecoregion.

Material and Methods

The study of benthic diatoms was performed in 8 lakes of central Italy: Albano, Bracciano, Bolsena, Vico, Martignano, Scanno, Salto and Turano (Fig. 1). While the first five lakes are volcanic origin, Scanno origin by a natural slide, Turano and Salto are generated by an anthropic impoundment. For each lake we selected two or three sites according also to dimensions.

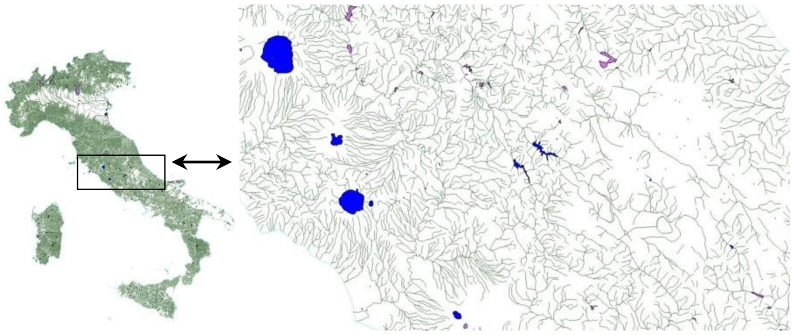

Fig. 1. Locations of the lakes studied in central Italy

Sampling was carried out from June to September during the 2012 and 2013. A total of 43 samples were collected in the littoral zone of lakes on three types of substrates, where available, in each site: stones or submerged macrophytes or artificial substrates that have been placed in water for at least three weeks. Diatoms were brushed from stones and artificial substrates with a toothbrush while macrophytes were cut and washed in a suitable container or grated carefully over the surface. The suspension was stored in a container and was prepared in 24 hours from the collection. 5-10 ml of samples were oxidated with hydrogen peroxide. The cleaned frustules were mounted in Naphrax and identified under oil immersion at a magnification of 1000. For each sample diatom were identified at species level and abundance was estimated counting 400 valves (Lange-Bertalot, 2012).

Data treatment

The EPI-L index was calculated by weighted average and calibrated on eutrophication pressure. EPI-L is the obtained on the basis of the following formula:

$$EPI-L = 4 - 2\frac{\sum_{i=1}^{n} a_i p_i v_i}{\sum_{i=1}^{n} a_i v_i}$$

(a= abundance of species in each lake; p= trophic weight, v= indicator value)

The sum of abundance of the n species used for the EPI-L calculation should account for at least 70% of the total abundance for each sample.

At first were calculated national boundaries for deep (>15m) and shallow lakes (<15m) shown in table. Boundaries used in this studies was those results from first procedures implementation relating to the Intercalibration exercise carry out "phytobenthos cross-GIG" (Marchetto, 2013) (Tab. 1).

BOUNDARY	EPI-L		EQR
	deep	shallow	
Reference	2.27	2.46	
H/G	1.70	1.85	0.75
G/M	1.14	1.23	0.50
M/P	0.57	0.62	0.25
P/B	0.11	0.12	0.05

Tab. 1. National boundaries for deep and shallow lakes results from the first implementation of Intercalibration Exercise

EQR final value is calculated as ratio between the values of EPI-L and those of reference according to the following formula:

$$EQR = \frac{EPI-L}{rif}$$

Result

A total of 188 diatom species and varieties were identified belonging to the main genera most common in the Mediterranean area (Fragilaria, Cyclotella, Amphora, Nitzschia, Staurosira, Gomphonema, Navicula, Epithemia). The most frequent species were: *Achnanthidium minutissimum* Czarnecki, Amphora *pediculus* Grunow, *Amphora inariensis* Krammer, *Cocconeis placentula* var *lineata,* Van Heurck, *Cyclotella ocellata* Pantocsek, *Cyclotella bodanica* Grunow, *Cyclotella atomus* Hustedt, *Fragilaria capuccina* var *vaucheriae* Lange-Bertalot, *Fragilaria famelica* Lange-Bertalot, *Fragilaria perminuta* Lange-Bertalot, *Epithemia adnata* Brébisson, *Epithemia sorex* Kützing, *Navicula cryptotenella* Lange-Bertalot, *Nitzschia fonticola* Grunow, *Nitzschia inconspicua* Grunow, *Staurosira brevistriata* Grunow, *Staurosira construens* Ehrenberg.

The impact of habitat type on species assemblages was evaluated: EPI-L has been calculated for all samples collected by different substrates (Tab. 3) but, according to the method, only 30 samples have exceeded the threshold of 70% of the species (Marchetto *et al*, 2013). For each lake was finally described ecological quality status (Tab. 2).

Lakes	Samples	EPI-L	EQR_{sample}	EQR_{lake}	Quality Status
Albano	AL_2 mc	1.31	0.57	0.55	G
	AL_2sb	1.22	0.53		
	AL_3mc	1.26	0.55		
	AL_3sb	1.31	0.57		
Bracciano	BR_1st	1.33	0.58	0.58	G
	BR_2mc	1.36	0.59		
	BR_3st	1.31	0.57		
Bolsena	BO_1st	1.34	0.59	0.57	G
	BO_2st	1.32	0.58		
	BO_3st	1.29	0.56		
	BO_3sb	1.29	0.56		
Martignano	MA_1mc	1.58	0.69	0.68	G
	MA_2st	1.56	0.68		
Vico	VC_1mc	1.30	0.57	0.58	G
	VC_1sb	1.32	0.58		
	VC_3st	1.32	0.58		
	VC_3mc	1.30	0.57		
	VC_3sb	1.38	0.60		
Salto	SA_1st	1.07	0.47	0.50	G
	SA_1sb	1.19	0.52		
	SA_2st	1.20	0.52		
Scanno	SC_1st	1.37	0.60	0.59	G
	SC_1mc	1.47	0.64		
	SC_2st	1.26	0.55		
	SC_2mc	1.26	0.55		
	SC_3st	1.44	0.63		
Turano	TU_1st	1.12	0.49	0.53	G
	TU_2st	1.16	0.51		
	TU_2sb	1.28	0.56		
	TU_3st	1.28	0.56		

n=site number; st=stones; mc=macrophytes; sb=artificial substrates

Tab. 2. EPI-L values and EQR results for each sample and ecological quality status for each lake studied

Discussion

The results confirm that the variances between samples collected at the same site on different types of substrates, even if present, don't affect the assessment quality of lakes. The ecosystems studied were assessed in good ecological status, except for two samples (TU_1st; SA_1st) relative to the Turano and Salto lakes; they present the lowest values of EPI-L and only these two samples results in moderate quality probably caused by the artificial characteristics of both ecosystems related to the use of water resource. It's important to underline that the final status of two lakes is good anyway. On the contrary, as expected, the highest values of the index were observed for both samples of Martignano, the lake less impacted.

Conclusions

Some studies have found differences in trophic status in relation to diatoms species composition from different substrates (Michelutti *et al*., 2003; Poulickova *et al*., 2004) instead in others study these did not appear (Danilov and Ekelund, 2000; Lim *et al*., 2001). Results of this study showed that ecological status assessment method EPI-L can be apply to diatom assemblages from different substrate stones, macrophytes and artificial substrates, giving the same indication of lake trophic status. Finally EPI-L method results a suitable tool for the ecological status assessment of lakes in Mediterranean ecoregion.

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Fish biodiversity and incidence of invasive fish species in an aquaculture and non-aquaculture site in Laguna de Bay, Philippines

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Keywords: fish biodiversity; invasive species; Laguna de Bay

Introduction

Laguna de Bay is the Philippines' largest inland water with 900 km^2 surface area. The lake has been assessed as hypereutrophic (Rohani and Roblo, 1984) to dystrophic (Barril and Tumlos, 2002). To make use of the lake's natural productivity a pilot aquaculture project started in 1971 (del Mendo and Gedney, 1979). The aquaculture industry in the lake rapidly developed, mainly using species not native to the lake. Since then, the lake has become a major source of fish in Metro Manila and the adjacent provinces.

An assessment of the impact of aquaculture in the lake showed increased total finfish biomass in the lake; ecotrophic efficiency of phytoplankton increased; and the calculated total net primary production decreased by a factor of two compared to the pre-aquaculture period (de los Reyes, 1993). The dominant species cultured in Laguna de Bay are introduced species. After more than 40 years the lake is now populated with non-native species including species that are considered invasive and nuisance. Many of these species were deliberately introduced for aquaculture and there are those that were considered accidental introductions like ornamental fish cultured in ponds within the lake's watershed.

To assess the impact of aquaculture in localized areas in the lake, a study was conducted to monitor diversity in the fisheries resources of the lake at two adjacent, but distinctly different sites: the West Cove (WC), an open fishery area, with no aquaculture and the East Cove (EC) which is an aquaculture site with cages for Nile tilapia, bighead carp, giant freshwater prawn. The location of the two sites is shown in Figure 1.

Materials and Methods

Fish traps made of bamboo poles and nets were installed in both sites and the total content of the traps were harvested every two weeks from April 2013 to March 2014. Biomass as well as the counts of each species were determined. From September to December 2013, the WC was overrun by massive bloom of water hyacinth which destroyed the trap

Figure 1. Laguna de Bay Map, left with detail on the location of the West Cove (WC) and East Cove (EC) fish traps

Diversity indices such as Shannon-Weiner Diversity (*H'*), Evenness (*J'*), Simpson's Index Similarity (*λ*), species richness (*s*) (Pielou, 1974 & 1975) were determined from the biomass of each species. Catch per unit effort (CPUE) were also determined for each site. Student's paired t-test was used to determine significant differences between the two sites at P<0.05.

Results

There were no significant differences between the two sites in species richness,s. However, significantly higher diversity was observed in the non-aquaculture site, WC, compared to the aquaculture site, EC as evidenced by the higher H', J' and lower □□□On the other hand significantly higher biomass of fishery resources were obtained in the EC than the WC. These are shown in Table 1.

Site		**Species richness, s**	**Shannon-Weiner Index, H'**	**Evenness, J'**	**Simpson Similarity Index, □**	**Catch per unit effort, g d^{-1}**
East Cove	Mean	7.6 ± 2.7	0.731 ± 0.412	0.369 ± 0.190	0.630 ± 0.230	5976 ± 7231
	Range	2 - 14	0.082 - 1.452	0.059 -0.695	0.281 - 0.974	422 - 29745
West Cove	Mean	8.5 ± 2.2	1.229 ± 0.384	0.595 ± 0.174	0.382 ± 0.167	412 ± 356
	Range	2 - 12	0.466 - 1.884	0.224 - 0.815	0.178 - 0.784	40 - 1270
P value		0.285	**0.001**	**0.001**	**0.002**	**<0.001**

Table 1. Mean and range of various diversity indices and catch per unit effort for the East Cove (aquaculture site) and the West Cove (non-aquaculture site). Computed P values are from Student's paired t-test

Introduced aquaculture species such as bighead carp *Aistichthys nobilis* showed a peak relative dominance of 98% in October 2013 in the EC as opposed to 58% in the WC in January 2014. Nile tilapia *Oreochromis niloticus* peaked at only 14% in the WC and at 77% in EC in December and August 2013, respectively. Non-cultured invasive species such as the janitor fish

Pterygoplichthys sp. had the highest dominance in May 2013 in the EC at 63% while the WC in February 2014 was at 27%. The knife fish *Chitala ornata* was highest in June 2013 at 65% in the WC but did not dominate at all in the EC. Other invasive species found in both sites were *Pangasius* sp. (23% in EC in June) and the cichlid *Sarotherodon melanotheron* (24% in WC in March 2014).

The species caught in the fish traps in both sites were grouped into three categories: Native- those that are native to Laguna de Bay; Cultured introduced - those that have been introduced to the lake for aquaculture ; and Invasive- those that have proven to be nuisance species, not exploited for commercial fisheries. Native species include gobies (*Glossogobius giuris, Giuris margaritacea*), silver therapon (*Leiopotherapon plumbeus*), Manila sea catfish (*Arius sp.*), snakehead (*Ophicephalus striatus*), freshwater prawn (*Macrobrachium lanceifrons*) and other species. Cultured introduced species include milkfish (*Chanos chanos*), bighead carp (*Aristichthys nobilis*), and Nile tilapia. Species considered invasive are the knife fish, the ciclid *Sarotherodon melanotheron*, janitor fish and *Pangasius* sp. Those species are summarized in Figure 2. In the EC, for the sampling period April 2013 to March 2014, the mean dominance for all cultured introduced species was 70%, with only an average of 13% for native species and the rest are considered Invasive. In contrast, in the WC, Native species had a mean dominance of 70% despite certain periods when Cultured introduced and Invasive species had some months alternately dominating the catch.

Discussion

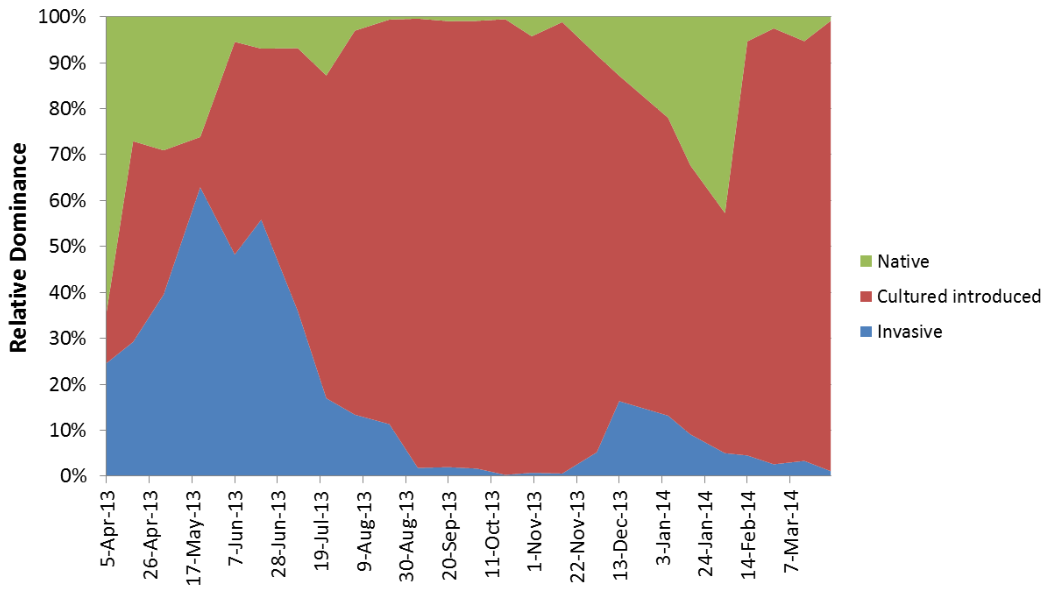
The negative relationship between aquaculture and biodiversity has been defined by Beveridge et al. (1994). Competition for resources such as habitat and natural feed resources between native species and the cultured species are among the primary reasons. This is evident from the results of this study where lower indices of biodiversity were observed in the EC compared to the WC. Introduced cultured species dominated the EC much more than the WC.

Species introductions for aquaculture for food fish, as in the case of Nile tilapia and bighead carp, and for ornamental fish trade, as the case of janitor fish and knife fish, among others has severely affected the diversity in Laguna de Bay. Although fish biomass in the EC was much higher than in the WC, this may be due to the protection afforded areas near aquaculture establishments to prevent poaching. On the other hand in open waters such as the WC, fishermen regularly catch fish in these “unprotected” areas which may explain the lower overall fish biomass found in the fish traps.

Aquaculture has been largely dependent on non-native domesticated species that have negatively impacted local biodiversity (Da Silva et al., 2009). Reducing the dependence on alien species for aquaculture and focusing on the domestication of commercially important native species is the way to go to enable expansion of the industry without the accompanying risks of species introductions (Ross et al., 2008).

Acknowledgements

Ms. Mildred Rutaquio and Mr. Federico Reyes assisted in the regular monitoring of the fish traps. Funds for the study was provided by SEAFDEC/AQD .



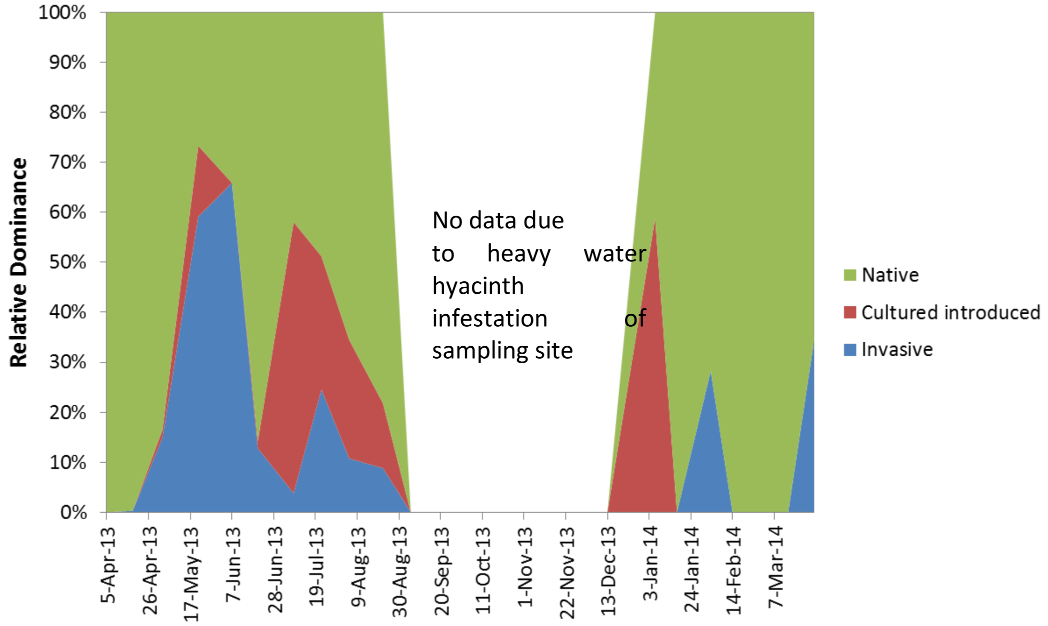


Fig. 2. Summary of relative dominance of fishery resources caught in fish traps in the East Cove (top) and West Cove (bottom)

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Zooplankton of Abkhazia lakes (Western Caucasus)

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Keywords: Zooplankton, Abkhazia, lakes

Introduction

Abkhazia is located in the south-western part of the Greater Caucasus. Republic is characterized by a pronounced vertical differentiation of climates and climate variability related with the mountainous relief. Territory of Abkhazia has a dense surface hydrographic network represented by mountain glaciers, rivers, lakes, swamps, springs of mineral and thermal waters (Ekba & Dbar, 2007).

There are many lakes on the territory of Abkhazia (over 130). Most of them are readily available or affordable. In the mountains there are lakes formed by rockslides that formed dams on rivers. Karst lakes are found in places of distribution of limestone. These lakes are round or funnel shape. In the coastal zone of the Black Sea are found shallow oxbow lakes formed by flooding of rivers.

We investigated eight lakes. These lake basins have different origins: karst (Lake Blue), glacial-tectonic (Big Riza, Small Riza, Mzy, Amtkel), former marine lagoon (Lake Skurcha) or artificial (Lakes Inkit, Soldatskoe), two lakes were formed in New-Afon cave. The surface area of the lakes was from 0.0003 (Lake Blue) to 1.47 km^2 (Lake Big Riza).

Most of the water bodies of Abkhazia have not been investigated. Therefore, the great scientific interest is the study of zooplankton communities. The aim of our research was to identify of zooplankton species, the calculation of the quantitative characteristics of zooplankton lakes Abkhazia.

Materials and methods

Samples of planktonic rotifers and crustaceans were collected during expeditions in August-September 2007-2012. In the pelagic zone of deep lakes samples were taken using Juday net (mesh size 100 microns). Consistently fished layers of hypolimnion, metalimnion and epilimnion. Samples were collected from shallow lakes straining 100-200 liters water through the Apshteyn network. Further processing of the samples was carried out with using standard techniques of hydrobiology (The methodical…, 1982). The identification was performed with using of Identification keys (Kutikova, 1970, Manuylova, 1964, Key…, 1994, 1995, 2010).

Results

Planktonic rotifers and crustaceans were presented 42 species in lakes. 27 species of zooplankton was met in freshwater lakes and 20 species - in salt.

We identified 22 species of rotifers (52% of total). Rotifers belong to four orders and eight families. Brachionidae family was most richly number of species (13), the rest of the family were represented 1-2 species. The highest species richness of rotifers observed in lakes, both freshwater (Lake Mzy, 9 species), and in saline (Lake Skurcha, 11 species), least of all rotifers was met in the lakes located in the caves.

Cladocera were presented 10 species (24% of the total) belonged to two orders (Anomopoda and Ctenopoda) and 4 families. For families Chydoridae, Bosminidae, Daphniidae applied to 3 species and to Sididae - 1 species. The greatest number of cladocerans noted in salt lake. Skurcha (6). In the cave lakes cladocerans were not met. In freshwater and saline lakes lived seven species of Cladocera.

Copepods was met 11 species (24%) also belonged to the orders Calaniformes (Diaptomidae family and Temoridae), Cyclopiformes (Fam. Cyclopidae) and Harpactiformes (Fam. Canthocamptidae). Crustaceans Fam. Cyclopidae, subfamily Cyclopinae are most rich number of species. The greatest number of Copepoda was identified in lakes Small Riza (4 species) and Big Riza (3). In freshwater lakes inhabited by seven species and in salted - 3.

Zooplankton abundance was small, usually no more than 15000 ind/m^3. The highest values of this index were observed in freshwater lakes (up to 260 000 ind/m^3 in Lake Riza) and in salt lake Inkit (14000 ind/m^3). In the cave lakes zooplankton abundance was extremely low. Groups of zooplankton abundance prevailed copepods and rotifers, and in freshwater lakes Blue and Small Riza was the predominant group of cladocerans. The highest zooplankton biomass was observed in freshwater lakes (in lake Riza was 10 g/m^3 sometimes). Groups of zooplankton biomass prevailed Copepoda or Rotifera.

Vertical distribution of zooplankton was uneven. In lake B. Riza highest density of zooplankton was observed in the epilimnion and metalimnion, and the biomass was highest in the epilimnion (0-4 m). In lakes S. Riza and Amtkel highest density was in the hypolimnion. In salt lake Skurcha zooplankton was concentrated in the surface layers of water that is due to lack of oxygen (25-30%) in the water column and the presence of hydrogen sulfide.

In samples taken of salted lake. Inkit, 10 types has been defined. Zooplankton abundance was 14030 ind/m^3, with a biomass of 0.01 g/m^3. The number of species, density and biomass of zooplankton groups prevailed rotifers dominated *Brachionus calyciflorus*.

Salt lake Skurcha characterized by a relatively high species richness of zooplankton, was found 17 species in this lake. Rotifera genus Synchaeta dominated by the ampleness in 2009, *Bosmina longirostris* - in 2010. Eurytemora sp. prevailed by biomass in 2009, in 2010 - the larval stage Calanoida. Zooplankton abundance varied by station from 120 to 630 ind/m^3, and biomass - from 0.00026 to 0.0024 g/m^3. In general, quantitative indicators are very low. Groups of zooplankton density and biomass prevailed Copepoda. Zooplankton relatively unevenly dispersed in the water column.

Zooplankton are extremely small in number in lakes situated in caves. Thus, in two lakes located in the New Afon cave were found a few individuals Copepoda identified as *Diacyclops bicuspidatus* (Claus) in 2008. Total number of zooplankton in the lake Anatolia was 1960 ind/m^3, when biomass was 13.71 mg/m^3. In another lake total zooplankton abundance was 160 ind/m^3, at biomass was 2.68 mg/m^3. In repeated research of lakes in 2010, representatives of zooplankton could not be found.

Discussion

Thus, lakes are different low diversity of zooplankton. The species composition of zooplankton was the most diverse in freshwater deep stratified lakes and some lakes with salt water. Overall zooplankton has low values of quantitative indicators. According to the literature for zooplankton mountain lakes also characterized by low biomass, dominance of large species (Daphnia, Calanoida), low species diversity, Glushchenko et al. (2009), Larson et al. (2009).

The data obtained can not be considered exhaustive, but they allow you to get an idea of the species composition and quantitative characteristics of planktonic rotifers and crustaceans lakes Abkhazia. Bodies of Abkhazia is a great variety of types, variety of hydrological and environmental conditions, so further research, including seasonal allow complement lists of identified species.

Acknowledgements

This work was funded by the grant allocated to Russian Foundation for Basic Research (grant № 13-05-90308).

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Limnological conditions and fish assemblage structures of the Tapi River oxbow lake in south Thailand

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Keywords: Thailand, Limnology, fish, oxbow-lake

Introduction

Oxbow lakes and floodplains add significant biodiversity, and are economically important to local people. Little is known about fish abundance and distribution in the floodplain of the Tapi River, particularly for the area of an oxbow lake (Lheknim, 2004). Thus, in the present study, physical and chemical characteristics of the water in an oxbow lake of the Tapi River floodplain were determined during various climatic periods (wet, rainy, and dry), and data on water qualities and fish composition were obtained for use as background for future sustainable use.

Materials and methods

Han Dum is a permanent oxbow lake located on the left bank of the Tapi River in the Kian Sa District, Surat Thani Province, south Thailand (8°43′09′′N, 99°14′39′′E). The maximum length is approximately 4 km, the width ranges between 15 and 50 m, and the maximum depth is 3.5 m. The substratum is predominantly mud and debris. Water input mainly comes from rainfall and the Tapi River. Emergent aquatic plants include *Phragmites australis* and *Eleocharis dulcis.* The banks of the main channels are wooded and shrubs. The region has a tropical monsoon climate, hot and humid. There are 2 seasons, i.e., the major rainy and intermediate dry season. The rainy season are further subdivided into a minor rainy season during the southwest monsoon (May to September), a principal rainy season during the northeast monsoon (October to January). The swamps are almost entirely flooded during the mid-late northeast monsoon and are restricted during the dry season.

Stationary lift net is widely used in this oxbow lake, with polyethylene nets of 8 × 8 m and 1.0 cm mesh size. Samples were collected by soaking the net underwater for 30 min. The net was then lifted and specimens were harvested. This procedure was replicated twice during each 3-h interval throughout the 48-h period. Samples were collected before and after sunrise, before and after noon, before and after sunset, and before and after midnight. Fish samples were collected directly from the lifted net, were identified at the species level, and were counted and weighed.

Environmental quality samples were collected on a monthly basis at 2 sampling stations in the oxbow lake and 2 sampling stations adjacent to the main Tapi River inlet of the oxbow lake. Water and air temperatures, pH, conductivity, alkalinity, and dissolved oxygen (DO) were recorded onsite. Water samples were transported to the laboratory, and total organic carbon (TOC), total nitrogen (TN), nitrate (NO_3-N), orthophosphate (PO_4-P), and silicate (SiO_2) contents were determined.

Monthly differences in water quality parameters between the oxbow lake and the adjacent river between June 2013 and May 2014 were investigated using two-way ANOVA. Differences in total individual numbers and total haul weights per lift net between sampling months in the oxbow lake were examined using one-way ANOVA. In addition, one-way analyses of similarities were performed to identify seasonal variations in the structures of fish assemblages on the basis of the presence/absence of fish species in each month. Similarity percentage analyses (SIMPER) were performed to test for the influences of individual species and similarities among seasons were investigated using correspondence analyses.

Results

Oxbow lake water levels were clearly defined by seasonal patterns, and from February to June, the lake was hydrologically isolated from the main river channel. However, a connection was established at the start of the southwest monsoon, following breach of the river levee and flow of water into the lake. This high water period gradually increased in July, possibly peaked between November and December, and water levels remained high for 5–6 months (Fig. 1A).

Minimum water temperature varied from 21 to 29 °C and maximum water temperature ranged from 28 to 37 °C. Minimum air temperature varied from 18 to 29°C and maximum air temperature was 33–37 °C (Figs. 1B and 1C). Water conductivity, DO, and PO_4^{3-} contents in the main Tapi River reach were significantly higher than in the oxbow lake and varied significantly between months (Figs. 1D, 1E, and 1F respectively). Alkalinity and total available carbon dioxide from the Tapi River reach were also higher than from the oxbow lake, but did not vary significantly between months (Figs. 1G and 1H). No significant differences in NO_3^-, TN, TOC and SiO_3^{2-} levels were observed between the oxbow lake and the Tapi River reach, although these constituents varied significantly between months (Figs. 1I, 1J, 1K and 1L).

Within the oxbow lake, significant positive correlations were observed between multiple variables, including conductivity and alkalinity, conductivity and water level, water level and alkalinity, maximum water temperature and phosphate content, and maximum water temperature and total organic carbon (Fig. 1M).

Total numbers of fish collected between August 2013 and December 2003 were significantly higher than those collected from other sampling dates (Fig. 2A), and the catch in October 2013 was the lowest. A comparable trend was also observed for average lift net haul weights (Fig. 2B), and the lowest catch weight occurred in October 2013. Significant differences in total numbers of fish/lift net haul and total weights/lift net hual were observed between the sampling months June 2013 and May 2014.

M)

	ALK	COND	DO	NO3	PO4	SIO3	TN	TOC	WLEVEL	MINWT	MAXWT	MINAT
COND	0.8353**											
DO	-0.2275	-0.3699										
NO3	0.3805	0.3275	-0.1617									
PO4	-0.2853	-0.1256	-0.1657	0.0894								
SIO3	0.237	0.1931	-0.2656	0.2802	0.1477							
TN	-0.1279	-0.0349	-0.3365	-0.1093	0.1622	0.1143						
TOC	-0.3651	-0.3494	-0.3018	0.0437	0.5095*	0.3073	0.0953					
WLEVEL	0.6641**	0.4731*	-0.1231	0.3762	-0.358	0.5034*	0.079	-0.1083				
MINWT	0.2473	0.204	-0.4048	0.2128	0.1838	0.4851*	0.1265	0.5425*	0.4808*			
MAXWT	-0.6022**	-0.4617*	0.0393	0.0246	0.6959**	0.0334	0.1768	0.6909**	-0.3972	0.1969		
MINAT	0.2404	0.2147	-0.219	0.3446	0.195	0.8276**	0.1554	0.4081	0.4965*	0.6665**	0.1196	
MAXAT	-0.5611*	-0.4832*	0.2451	-0.1073	0.5295*	-0.4491*	-0.3001	0.2757	-0.7083**	-0.0703	0.5608*	-0.3021

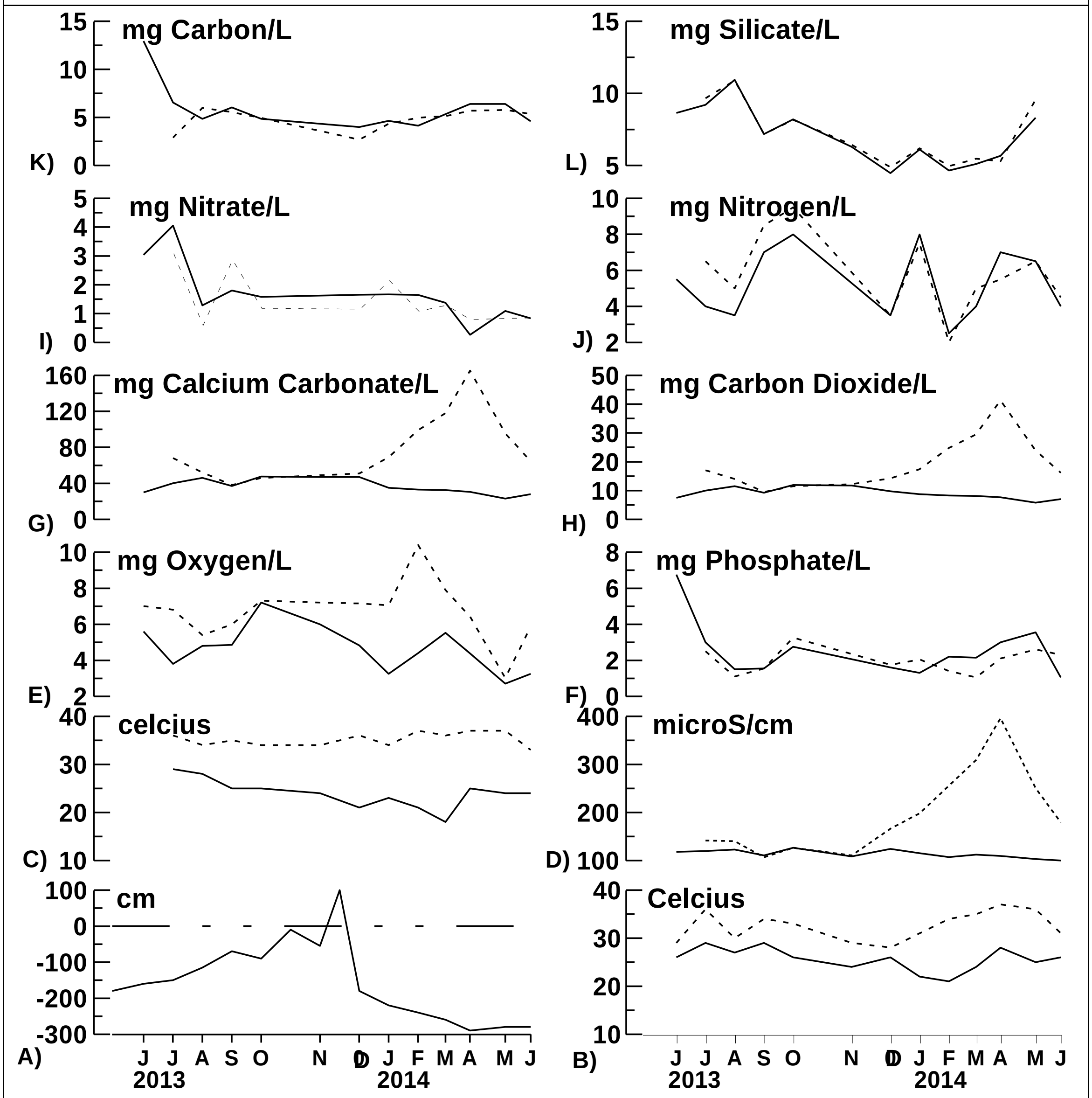

Fig. 1. Temporal variations in water quality of the oxbow lake (Solid Line) and Main Tapi River (Dash Line) in south Thailand, June 2013 – May 2014. A) Water level, B) Water Temperature, C) Air Temperature, D) Conductivity, E) Dissolved Oxygen, F) Phosphate, G) Alkalinity, H) Total Carbon Availability (TIC), I) Nitrate, J) Total Nitrogen, K0 Total Organic Carbon, L) Silicate, and M) Correlation Coefficient between parameters (asterisk= significant correlations)

More than 75 species were recorded from between June 2013 and May 2014, and the highest total species number was recorded in September 2013. Species richness remained relatively high until March 2014 and total numbers of species were subsequently reduced (Fig. 2C). However, no significant differences in total fish species assemblages were observed between seasons. Moreover, analyses of similarity failed to detect differences in species composition between seasons during the given sampling dates (Global R = 0.01008, p = 0.4506; Fig. 2D). Typical correspondence analysis plots for these comparisons are presented in Figure 2E.

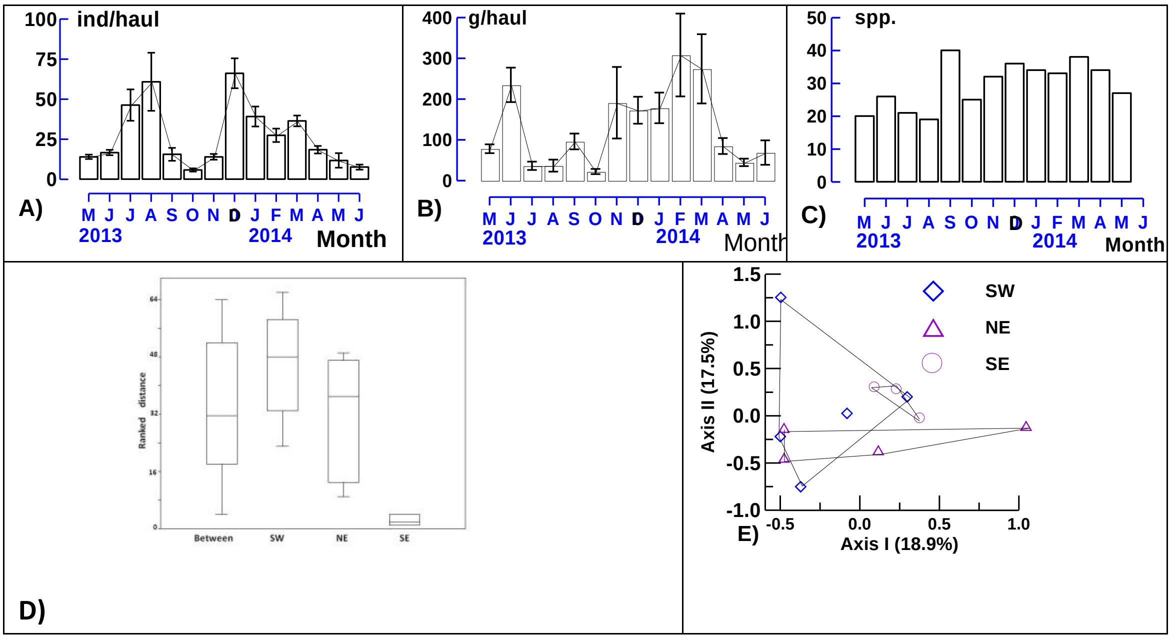

Fig. 2. Temporal variations in fish assemblage of the Tapi River oxbow lake in south Thailand between June 2013 and May 2014. A) Average total numbers of fish/Lift net hual, B) Average total weights/Lift net hual, C) total numbers of species, D) Box plot of ranked similarity distance among Monsoon Season (SW= southwest, NE= Northeast, SE= Southeastery Wind), and E) Correspondence Analysis of fish assemblage among Monsoon Season

Discussion

Physicochemical characteristics of water are known to affect the distribution, abundance, and composition of fish in aquatic ecosystems. In this study, significant differences in conductivity, DO, NO_3^-, PO_4^{3-},TN, TOC, and SiO_3^{2-} levels among sampling months were observed, indicating significant seasonality (Fig. 1). These variations in oxbow lake water contents were clearly correlated with water levels, and reflected the condition of the connection between the lake and the adjacent river (Tockner et al., 1999).

During the SW monsoon, water started to flood the lake, and species richness increased and peaked in the proper rainy season. Subsequently, species richness declined with isolation of the lake from the main river (Figs. 1A and 2C), confirming that fish species diversity of oxbow lakes is dependent on the connectivity between the lake and the adjacent river (de Silva et al., 2013). The flooding season expands the floodplain habitat, includes the oxbow lake, and improves the availability of feeding and nursery habitats (Junk et al., 1989). Because the oxbow lake is located in a floodplain that is covered with emergent plants and swamps, it may provide more protective habitats that support more diverse populations.

In summary, we found that seasonality of environmental conditions reflected variations in fish assemblage patterns, which also had clear seasonal trends. The present absence of significant differences in fish species richness between seasons may reflect the dimensional limitations of present–absent data, and warrant further studies using multi dimensional analyses.

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Lake Shorezone Functionality index (SFI) and macrophytes in the Protected area of Lungo and Ripasottile lakes

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Keywords: Lakes, Protected Area, Macrophyte, Shorezone Functionality Index (SFI), *Nupharetum*

Introduction

Natural and artificial lakes represent the main fresh water reservoirs immediately available on the hearth surface and the key components of the global water supplying. These ecosystems have a considerable interest at ecologic and evolutive level because of the demographic and economic development which expose them at an heavy environmental risk (Mastrantuono & Mancinelli, 2003). Biological indicators are used to assess the environmental quality of aquatic ecosystems as required by *Water Framework Directive 2000/60/*EC (Europe, 2000). The macrophytes are used in Europe to assess the quality of the lakes water as their high sensitivity to different pollutants (Seddon, 1972; Haslam, 2000). The index used to evaluate the quality of the italian lakes is the *Macrophytes Italian Multimetrics Index* (MacroIMMI), an index based on multiple metrics but mainly developed for alpine lakes (Oggioni et al., 2009). The WFD require also a idromorfological and physical-chemical parameters to support biological elements. The Lake *Shorezone Functionality index* (SFI) represents a tool supporting the definition of ecological quality (Europe, 2000) as the preservation or widening of the wetland can be of valuable aid for achieving the objectives of the WFD (Siligardi et al., 2011).
The aim of the study was to assess the environmental quality of the Lungo and Ripasottile lakes by investigating macrophytes communities and hydromorphological functionality with SFI index.

Materials and methods

The SFI evaluation and the macrophyte sampling were performed in September 2013 when the aquatic vegetation and riparian flora of the Ripasottile and Lungo lakes are at the greatest development.
The two lakes were divided into homogeneous traits in order to evaluate the functionality of the specific shorezone traits. Seven tracts for Ripasottile and five for Lungo have been identified and evaluated according to the SFI index manual (Siligardi et al., 2011). Further, the physical-chemical parameters like temperature (T), pH, dissolved oxygen (O_2) and Conductivity were evaluated using a multiparameter probe (556 MPS YSI) and chemical parameters as total Phosphorous(P), Nitrate(NO_3^-), Ammonium (NH_4^+), Chemical Oxigen Demand (COD) were

evaluated with a Merk commercial kit and Biological Oxygen Demand (BOD_5) with WTW OXiTop.

Macrophytes analysis was performed, for both lakes, evaluating the total percentage of coverage and the percentage coverage of the individual macrophyte species and it was calculated the MacroIMMI index (Oggioni et al., 2009). Macrophyte species were sampled according to a standard procedure (UNI, 2008) and subsequently identified at species level by the use of a dichotomous key (Pignatti, 2003).

Results

The results of this study show that Shorezone functionality resulted excellent for both lakes in all the tracts (Fig. 1).

The physical-chemical and chemical results show similarity between the waters of the two lakes .

Macrophytes were found mainly on the riparian zone and few species were found in the first meters of the water, probably due to the high turbidity ,deeper zones and substrate typology silt-clay.

A total of 6 species typically of Riparian zone, *Phragmites australis* Lam., *Sparganium erectum* L., *Persicaria hydropiper* L., *Symphytum officinale* L., *Iris pseudacorus L., Cyperus longus* L. were found in the lake Ripasottile and 4, 2 species typically of the riparian zone *Cyperus longus* L., *Phragmites australis* Lam. in Lungo lake are identified.

The total macrophytes coverage was low in both lakes: 30% in Lungo Lake and 15% in Ripasottile lake. As far as the coverage of *Phragmites australis* Lam. represents most of macrophyte coverage of the riparian zone of both Lungo lake and Ripasottile lake. In Lungo lake it was found *Nymphaea alba* L.*,* which together with *Nuphar lutea* L., makes a rare association, named *Nupharetum,* in Latium ecosystems.

It was not possible to apply MacroIMMI Index to evaluate water quality of two lakes because macrophyte species detected in this study, were only partially included, only *Nymphaea alba* L. and *Nuphar lutea* L. in the index list. in fact the index was mainly build on species typically of Alpine ECO Region.

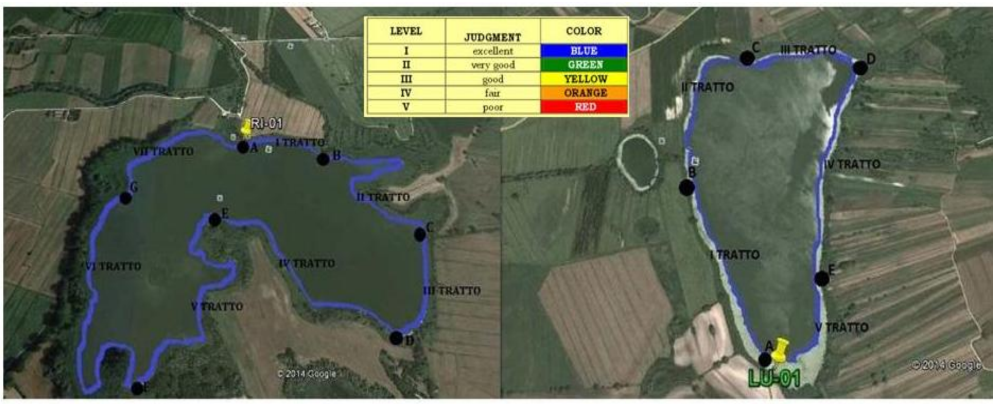

Fig.1. Results of SFI applied on the Ripasottile and Lungo lakes

Discussion

Lungo and Ripasottile lakes represent a natural reservation important for its potentiality in the biodiversity and ecosystems protection. On the whole, this study shows the abundant presence of macrophityc communities in both lakes along the riparian areas and in the first meter of water.

The constant presence of *Phragmites australis* L. in both lakes should not be underestimated as this macrophyte acts as an "oxigen pump" mediating the transfer of oxigen from aereal part to the rizosphere and increasing the aerobic degradation of organic substances and nitrification. (Hwa Lee & Scholz, 2006).

In Lungo lake, the presence of *Nymphaea alba* L. is of relevant importance, as this species is extremely rare in the Latium ecosystems. With the more common, *Nuphar lutaea* L. it makes the *Nupharetum,* a rare association protected in the framework of Habitat Directive (Europe, 1992).

The national method for macrophytes of lakes is still in the experimentation phase and is essential to calibrate it for each ECO Region present in national territory.

The present study is a contribution to implementation of MacroIMMI index application.

The use of SFI index allows to move the attention to the external part at the border of water body, to the dry zone and its surroundings and thus represents an innovative operation considering more extensively the lacustrine body. The SFI index tries to conjugate in an easy way the different dimension of a lake and to increase the knowledge on the ecotonals relationships between two close ecosystems.

In this study, Shorezone Functionality Index (SFI) resulted excellent for the two lakes, thus indicating that the riparian zone represents an important buffer for runoff and leaching derived by human activities in the whole of the Natural reservation of Lungo and Ripasottile lakes. However, the continuous pressure on the wet biotopes could in future not be sufficient to preserve the biodiversity.

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Environmental quality assessment of Posta Fibreno Lake Protected area

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Keywords: Diatom communities, environmental quality, integrated approach, protected area

Introduction

Aquatic ecosystems in protected areas help the preservation of biodiversity and play an important ecological role in the landscape due to their function as biological corridor and source of fauna recolonisation (Mancini et al., 2005). The assessment of environmental quality of these ecosystems is important for following reasons: 1) to investigate the real condition of water bodies in protected area: rarely parks were created to preserve the functionality of freshwater aquatic ecosystems; 2) it is required by Water Frame Directive (CEC, 2000); 3) protected area could be a good pilot area where apply restoration and management planes.
The study area of this work is the Protected Area of Posta Fibreno lake: it was created in 1983, in order to preserve the floristic and faunistic biodiversity of this lake. It has karstic orgin that generated particularly environmental conditions (ie water temperature is 10° C is around 10°C throughout the year), that allow the life of different plant (*Hippuris vulgaris*) and animals (*Salmoni fibreni*) and the nidification of different birds (*Fulica atra)*. The environmental quality was assessed by an integrated approach that included biological and microbiological indicators, supported water quality variables. Diatom were chosen as biological indicator: they are unicellular algae of *Bacillariophyceae* class and due to their sensitivity to eutrophication and organic pollution are one of the biological elements required by the Water frame Directive for ecological status the assessment (ie. Prygiel & Coste 1999). Furthermore as microbiological indicator were chosen Enterococci and *E. coli:* they are commonly used to detect faecal pollution (Berg, 1978, EU, 2006).

Materials and methods

Seven sites were selected around Posta Fibreno Lake and two sampling were performed in 2007, in hot and cold season.

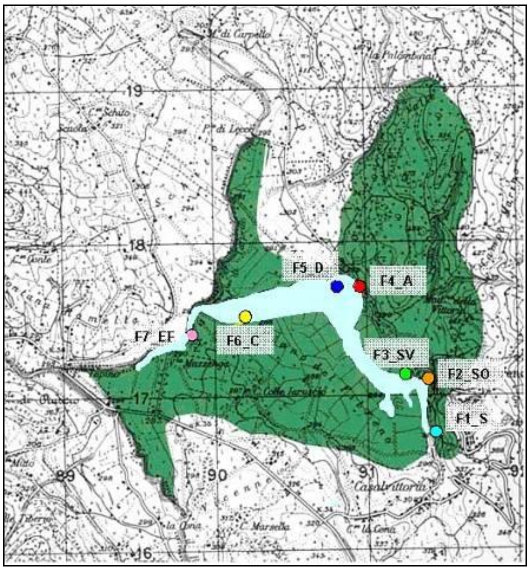

Fig. 1. Localization of sampling sites

Diatom samples were collected from six sites, except from F7_EF. Samples were treated using H_2O_2 and HCl; diatoms were identified at species level using iconographic guides, and 400 valves were counted (Krammer & Lange-Bertalot, 1986-2000; CEN-EN 13946, 2005 e pr-EN 14407, 2004). Environmental quality was assessed by Trophic index (Rott, 1999) and *Indice de Polluo Sensibilitè* (Cemagref, 1982), already used for the ecological status assessment of river (Mancini & Sollazzo, 2009).

Water quality parameters, such as, pH, and Conductivity and Dissolved Oxygen were measured in situ using a portable probes for multi-parameter. While nutrients, nitrate (NO_3^-), phosphate (PO_4^{3-}), ammonium (NH_4^+), were analyzed using Merck Spectroquant kits and concentrations were determined photometrically.

E. coli and Enterococci were detected, using the membrane filtration technique (APHA, 2005) and each parameters were run in triplicate and results are expressed as mean of colony forming units (*CFU*).

Results

Diatom communities

A total of 59 species and varieties have been identified, belonging to following genera *Navicula, Gomphonema Amphora, Achnanthes, Cymbella, Epithemia, Stauroneis, Diploneis, Eunotia, Cocconeis.*

Environmental quality was assessed using two biotic index, *Trophic index* (TI) and *Indice de Polluosensibilitè* (IPS) (Fig. 2), two samples of cold season F1_S, F2_SO were not included in index calculation due to their low concentration of diatoms. TI, based on the sensitivity of diatoms for nutrients classified all the sites in moderate or poor environmental conditions; instead IPS, a quality index that takes into account mainly sensitivity to organic pollution classified sites in high or good quality, except for one site in cold season that resulted in moderate conditions (F4_A).

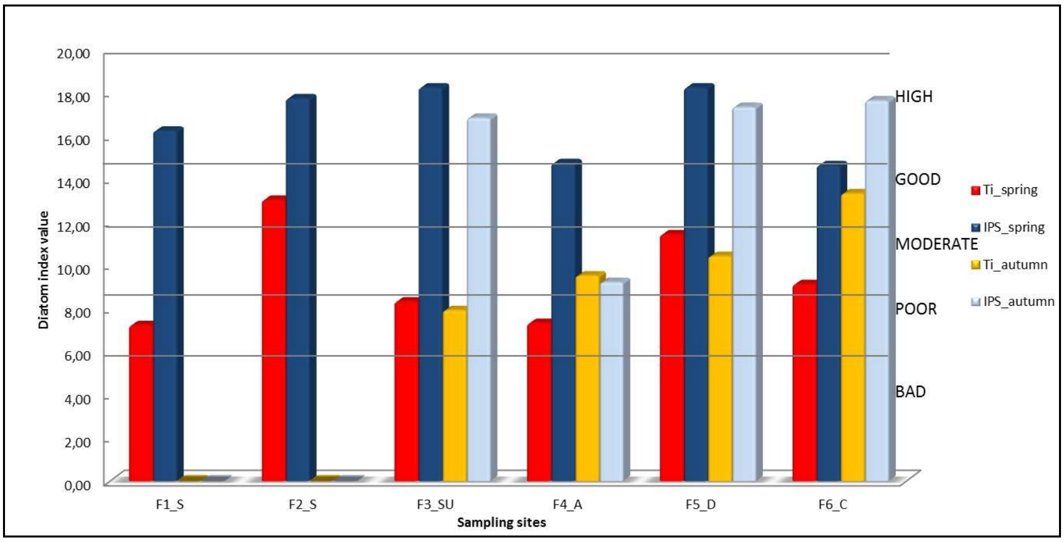

Fig. 2. Environmental quality based on application of two biotic index diatom communities

Microbiological and water quality variables analysis results

Results of microbiological analysis and water quality variables are reported in table below (Tab. 1).

Microbiological results showed a variability from hot to cold season in F6_C site for of *E. coli.* High values of Enterococci concentration were observed on F1_S and F7_EF sites.

Water quality variables results showed similar values of conductivity, pH and Dissolved Oxygen in the studied sites and a significant seasonal variation was not detected; nutrient analysis results showed light concentrations of Nitrates in all samples, except in F6_D.

Sampling sites	*E. coli* *CFU*/100ml	Enterococchi *CFU*/100ml	Conductivity (µS/cm)	pH	O_2 (mg/L)	NO_3^- (mg/L)	PO_4^3 (mg/L)	NH_4^+ (mg/L)
				Hot season sampling				
F1_S	1*10	0	659	6.74	8.84	3.43	0.09	0.01
F2_SO	1*10	1.3*10	653	6.88	7.72	3.13	0.04	0.05
F3_SU	0	6	645	6.72	8.87	3.04	0.04	0.01
F4_A	8,5	1.2*10	764	7.00	9.01	2.67	0.11	0.04
F5_D	0	1*10	663	6.85	11.72	2.24	0.11	0.01
F6_C	5.8*10	1.4*10^2	600	7.06	10.25	0.94	0.05	0.02
F7_EF	0	3.2*10	693	6.79	15.5	2.42	0.03	0.03
				Cold season sampling				
Sampling sites	*E. coli* *CFU*/100ml	Enterococchi *CFU*/100ml	Conductivity (µS/cm)	pH	O_2 (mg/L)	NO_3^- (mg/L)	PO_4^{3-} (mg/L)	NH_4^+ (mg/L)
F1_S	8	2.01*100	669	6.91	7.9	2.94	0.58	0.01
F2_SO	1	0	644	6.89	8.3	2.53	0.11	0.02
F3_SU	0	1	637	6.90	7.59	2.80	0.2	0.01
F4_A	1.4*10	6	679	6.91	8.85	1.89	0.11	0.02
F5_D	0	1	672	6.98	8.83	2.26	0.11	0.01
F6_C	2.13*10^2	2.1*10	699	6.95	9.68	1.24	0.11	0.02
F7_EF	1.7*10	4.00*10^2	699	6.91	9.9	1.89	0.11	0.01

Table 1. Microbiological and water quality parameter analysis results

Discussion

The environmental quality of Posta Fibreno Lake was assessed by and integrated approach that takes in to account biological, microbiological indicators supported by water quality parameters. Diatom communities found in this study are mainly composed by sensitive species to organic pollution and eutrophication *Achnanthes minutissima*, *Cocconeis placentula*, *Diatoma mesodon* (Dell'Uomo, 2004, Van Dam *et al*., 1994), indicating an overall good environmental quality of this lake. Furthermore these algae were also able to detect the light concentration of nutrients (Tab. 1): Trophic index, results classified all the sites in a moderate or poor environmental quality. Organic pollution was detected by diatom communities, applying the *Indice de Polluosensibilité*, only in one site F4_A in autumn season: indeed it classified remaining sites in good or high quality. Microbiological results suggested the presence of spot and point sources of pollution. Contamination from *E. coli* was probably due to anthropogenic origin as increase during hot season; instead of Enterococci was probably due to the livestock activities. The results of this study reveal that overall the lake Posta Fibreno is in a condition of good environmental quality. The light nutrient concentrations could be attributed to the nature of the karst terrain. The presence of, organic pollution, although point, that does not compromise the overall quality of this lake, should be considered, anyway, a warning: the environmental status of this lakes should be in a high quality in order to represent a reference condition for aquatic ecosystems that are not located in protected areas.

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Artificial substrates for the sampling of diatom communities in transitional water

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Keywords: diatom sampling, artificial substrates, transitional waters

Introduction

From the emanation of Water Frame Directive (CEC, 2000), standard sampling procedures and assessment method have been developed for the analysis of diatom community of river and lakes (En 13496, 2005, Kelly et al 2006, Mancini & Sollazzo 2009, Marchetto et al., 2013).

The term of Transitional waters included estuaries, coastal lakes and lagoons: the environmental differences (hydromorphology, geology and hydrodinamism) of these ecosystems represent a challenge for the development of methods of sampling and analysis of biological elements (CEC, 2000) .

Artificial substrates: have been suggested for diatom sampling of river and lakes whereas, natural susbstrates, such as stones or macrophytes are not present (En 13496, 2005), and they are compliant to Water Frame Directive requirements. This study aims to set methods for diatom sampling in transitional waters, using artificial substrates.

Materials and methods

This study was performed on Orbetello Lagoon; a coastal lake located in Tuscany, Central Italy, with a surface area of 27 km^2, with a deep, on average, of 1,5 m.

4 sites were selected H18, H29, H32, H40 where to place artificial substrates.

Artificial substrates, Hester-Dendy modified substrates (e.g. Cairns & Dickson, 1971; Battegazzore, 1994, Buffagni *et al*., 2000), used in this study are 10 plates of plexiglass, each plate having an area of 100 cm^2 and a thickness of 3 mm. The plates are far 7 mm and linked by a rope or a metal string. A see-through material, as plexiglass, was chosen in order to allow the growth of diatoms in each of them, aiming to investigate how the effects of light, turbidity and deep influence these communities. Artificial substrates were collected after one month, from the surface of plates diatom were scraped using a toothbrush. A permanent slide was prepared for each plate.

Diatom samples were treated using hydrogen peroxide (30 % H_20_2) hydrochloric acid (37% HCL) (EN 13946, 2005): Diatoms were identified at species level and counted up to 400-500 valves (EN 14407, 2004). Identifications were based on iconographic guides (Krammer & Lange-Bertalot, 1986; 1988; 1991a; 1991b; Witkowski *et al*., 2000, Danielidis *et al.,* 2003).

Results

A total 24 slides were analysed: all 10 plates of H18 and H40 samples and the first and the last one of H29 and H32. 35 freshwater, brackish and marines diatom species and varieties were identified belonging to several genera (Tab 1).

Genus	N° species
Achnanthes Bory	1
Amphora C. G. Ehrenberg	2
Ardissonia G. De Notaris	1
Brachysira Kützing	1
Cocconeis C.G. Ehrenberg	2
Diploneis C.G. Ehrenberg	1
Fragilaria Lyngbye	1
Grammatophora C.G. Ehrenberg	3
Licmophora C.A. Agardh	3
Mastogloia Thwaites	7
Navicula Bory de St. Vincent	5
Neosynedra D.M. Williams & F.E. Round	1
Nitzschia Hassall	3
Pleurosigma W. Smith	1
Rhopalodia O. Müller	1
Seminavis D.G. Mann	1
Toxarium Bailey	1

Table 1. Diatom genera and number of species identified in this study

Diatom community composition changed from up to down as reported by the comparison from the first and the last slide of each sample (Fig. 1).

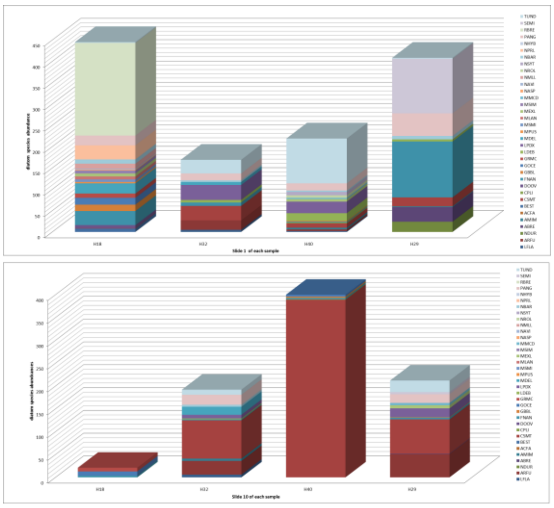

Fig. 1. Abundance of each diatom species identified in slide 1 and slide 10 of each sample.

The results of the identification and counting of the 10 slides of H18 e H40 showed a variation of diatom communities: they gradually changed in terms composition and abundances of species (Fig.1).

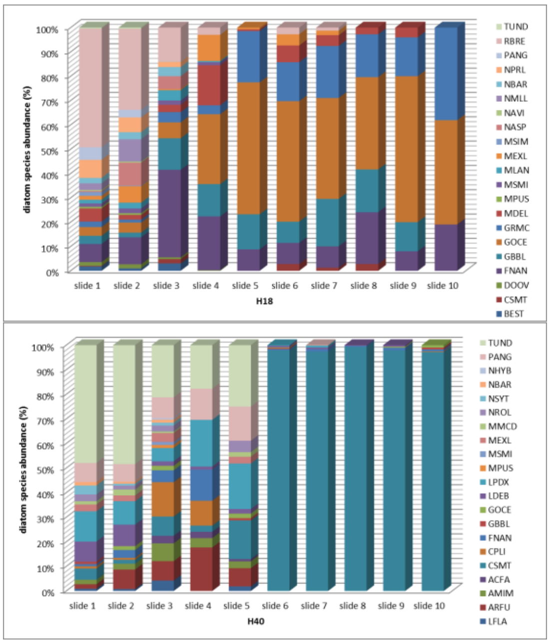

Fig. 2. Diatom species abundance(%) found in each plate of sample H18 and H40

Discussion

Diatom community structure composition and abundance of each species changed from the surface to the bottom: from on average of 17 species in each sites number of species decrease to a mean of 8 (Fig. 1).

The results of the analysis of all the ten slides of H18 e H40 (Fig. 2) showed the variation of diatom community structure: in H18, first slides are dominated by planktonic species *Rophalodia Brebissoni* Krammer (RBRE) and the last ones are characterized by significative abundance of benthic species *Grammatophora oceanica* Ehrenberg (GOCE), *Grammatophora gibberula* GGBL Kützing, *Grammatophora macilenta* Wm Smith (GRCM) (Denys, 1991). Concerning H40, the high concentration of planktonic *Toxarium ondulatum* J.W. Bailey (TUND) detected in the first slides progressively reduced into the following ones, instead benthic species *Cocconeis scutellum* Ehrenberg (CSMT): it is the most abundance from slide number 6. In this case, the natural substrates of this site, where plates were placed, *Posidonia oceanica* (L.) influenced the community of diatom: this angiosperm is one of suitable substrates for the growth of *C. scutellum* (De Stefano *et al.,* 2008).

Due to the lack of natural available substrates more suitable for diatom such as stones, pebbles and macrophytes in transitional water, artificial substrates resulted as a useful tool in order to be able to compare data from different ecosystems. The limited studies of diatom communities in Mediterranean wetlands underscore the poor understanding of the autecology of diatoms in these ecosystems (Rovira *et al*., 2009, Sabater *et al.,* 1990, Tolomio *et al.,* 2002), in this contest artificial substrates could improve the knowledge of diatom distribution and the effect of environmental parameters on these algae.

In this study artificial substrates were found to be a suitable tool for diatom sampling in transitional waters: diatoms colonized all plates of each sample.

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A new feral population of *Trachemys scripta* in Northern Italy?

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Keywords: *Trachemys*, slider turtle, reproduction, capture-recapture, Italy

Introduction

Trachemys scripta subspecies are massively imported in Europe as pets (Ballasina, 1995), and often released in the wild by owners. In Italy, slider turtles established free-living populations in many lakes, ponds, rivers and wetlands (Ballasina, 1995). In some areas successful reproduction has been reported (Agosta & Parolini, 1999; Ferri & Soccini, 2003; Ficetola et al., 2003; Monti, 2010).

In small urban and periurban parks, human-made and semi-natural wetlands often host slider turtles at high density, with negative impacts on freshwater ecosystems (Lapini et al., 1999; Marangoni, 2000; Petterino et al., 2001).

We conducted this study to estimate consistency and species composition of turtles population hosted into the artificial lakes and ponds of the Parco Nord Milano (Italy, Lombardy, Milan Province), where slider turtles occur since several years but population size, sex-ratio and reproductive status have never been investigated.

Materials and methods

We captured slider turtles with basking traps from April to August 2013 at four trapping sites within the park. We visited each trap every two or three day between 11.00 AM and 03.00 PM, when the basking activity is greater (Cady & Joly, 2000). During each visit, we also captured turtles using landing nets. Each individual was weighted and sexed according to secondary sexual characteristics such as claws and tail (Ernst & Lovich 2009). We measured the straight line plastron length (SPL), the minimum straight carapace length (SCLmin) and the straight carapace width (SCW) of each individual (Bjordan & Bolten, 1989), with calipers.

We filed unique notch combinations into the marginal carapace scutes, to unambiguously mark each animal.

In order to estimate the overall number of turtles, we used the capture-mark-recapture (CMR) model for close populations provided by the software NOREMARK (JHE Closed Population Model Estimation), given that for each individual capture and recapture occurred within the same site.

Finally, we estimated the number of potential breeders by plastron length according to Gibbons (1990).

Results

We marked a total of 170 turtles, belonging to three exotic genera. 156 are slider turtles: 36 were red-eared sliders (*T. scripta elegans*), 16 were yellow-bellied sliders (*T. scripta scripta*), 7 were Cumberland sliders (*T. scripta troostii*), and 98 were *T. scripta* hybrids. We also found 10 individuals of *Graptemys sp.* and 4 of *Pseudemys sp.* (fig 1).

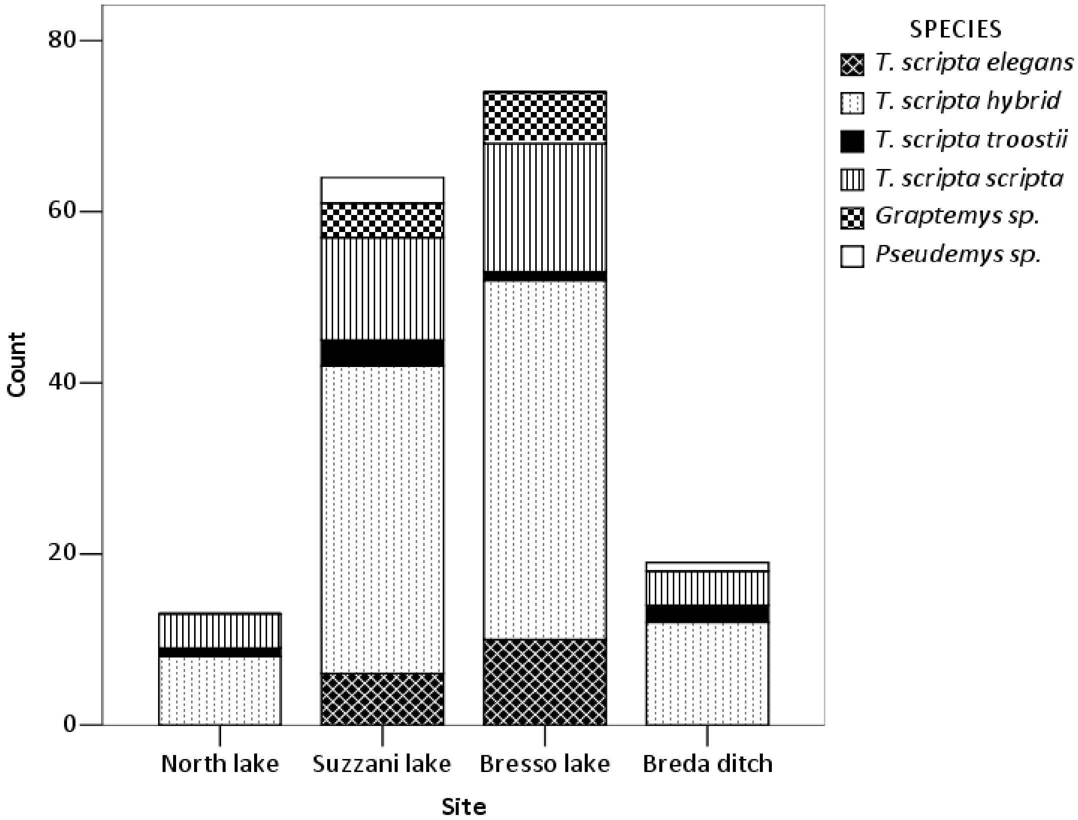

Fig. 1. Species distribution into the four wetlands of the Park

Using our capture-recapture data, the software NOREMARK estimated the following overall population [best (95 % confidence interval)]: 13 (13) in the North lake; 84 (73-102) in the Suzzani lake; 106 (90-129) in the Bresso lake; 21 (19-26) in the Breda ditch.

For *T. scripta* spp. specimens, we obtained the following morphometric measures (table 1). Among them, six slider turtles have a SPL between 16 and 51 millimeters. 4 are *T. scripta* hybrids (SPL 16 to 51 mm, µ 33.75 ± 14.32 s.d.), 1 is *T. s. elegans* (SPL 43 mm) and 1 is *T. s. scripta* (SPL 42 mm).

	North lake	Suzzani lake	Bresso lake	Breda ditch
SPL	96.92	119.19	110.99	88.39
n	13	57	67	18
(SD)	38.28	35.30	42.45	34.38
Min. - Max.	52-168	43-188	16-210	33-158
SCLmin	108.31	128.35	121.04	95.56
n	13	57	67	18
(SD)	42.00	36.37	45.46	38.67
Min. - Max.	59-180	47-201	21-221	35-166
Weight	325.00	472.73	448.48	266.18
n	12	55	66	17
(SD)	252.71	307.59	389.45	217.40
Min. - Max.	50-850	50-1500	50-2000	50-750

Table 1. Mean, standard deviation (SD) and minimum-maximum range of straight line measurements of plastron length (SPL, cm); carapace length (SCLmin, cm) and weight (g) of the trapped slider turtles, grouped by trapping site. N is the number of measurement

Discussion

Sexual maturity in *T. scripta* spp. is strictly influenced mainly by body size rather than age (Cagle, 1950; Moll, 1979; Wilbur & Morin, 1988; Gibbons & Greene, 1990), so we inferred the number of potential breeders using only straight plastron length of captured specimens. According to Gibbons (1990), females can be considered mature with a plastron length of 160–190 mm, whereas males reach maturity with a plastron length of 80-130 mm. These measures referred to *T. s. scripta* but can be extended to *T. s. elegans* (Tucker & Moll, 1997) and reasonably also to *T. s. troostii*, as well as to the *T. s.* hybrids.

According to these data, we speculated that the park could host a (minimum) total number of potential breeding sliders from 18 (16 males, 2 females) to 59 (44 males, 15 females), considering marked turtles only.

Although during this study we did not find evidence of successful reproduction, the six smallest specimens could be considered a sign of recent *in-situ* reproduction, because slider turtles are usually released when they reach maturity. The smallest hybrid in particular (SPL 16 mm) had similar dimensions to the hatchling slider turtles reported in Ficetola et al. (2003) and in Ferri & Soccini (2003). The smallest *T. s. elegans* is also an interesting case: the import of this subspecies was banned in Europe in 1997, so it can be either a juvenile born in the park or a recent release.

It is interesting also that turtles don't move from one wetland to another, even if sampling sites are not far from each other: three areas (Suzzani lake, Bresso lake and Breda ditch) occurs within a distance of only 500 meters. Only the North lake is more than 1000 meters far from the other three.

Acknowledgements

We thank Riccardo Gini, director of Parco Nord Milano, and all employees of the park, especially Gianmario Bernasconi, Francesco Carbone and Marco Siliprandi for their help. We thank PhD Francesco Ficetola and Stefano Scali for their valuable advice. We also thank PhD Matteo Capodicasa and Thania Manfredi.

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Evolution of the *Dikerogammarus villosus* (Sowinsky, 1894) invasion in Lake Garda (Northern Italy)

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Keywords: Biological invasion, *Dikerogammarus villosus*, *Echinogammarus stammeri*, Lake Garda, freshwater amphipods

Introduction

Over the past decades the invasive Ponto-Caspian gammarid *Dikerogammarus villosus* (Sowinsky, 1894) spread throughout large rivers of central Europe, thereby rapidly displacing most of the native gammarid species (Hesselschwerdt et al., 2008) which share similar microhabitats. The “killer shrimp” is among the most successful invaders of aquatic ecosystems in Europe (Bij de Vaate et al., 2002) and was observed for the first time in Lake Garda and in the nearby watercourses during the 2003 (Casellato et al., 2006). Findings of *D. villosus* in Tuscany (Central Italy) (Tricarico et al., 2010) in 2008 demonstrate that this invader has extended its range very quickly also in Italy, becoming a serious threat for the survival of indigenous species, like the gammarid *Echinogammarus stammeri* (S. Karaman, 1931). Indeed, in Lake Garda *E. stammeri* was segregated from the littoral zone to higher depths due to competition, especially in the southern basin but also likely in the northern (Casellato et al., 2008).

Ten years after the first record and monitoring, we have checked the distribution of *D. villosus* and *E. stammeri*, to verify the evolution of the invasion. A quantitative study was carried out from June to September 2013 in the littoral area reachable without boat, to assess occurrence and densities of the two gammarid species and to compare past and present situation. Finally, qualitative confrontations between previous information (Casellato et al., 2008) and new findings in sublittoral and profundal environments were discussed.

Materials and methods

Sampling operations were performed in June and September 2013, at seven stations along the edge of the Lake Garda (Fig. 1). Sites were chosen in agreement with previous works to allow evaluation of differences and they were concerned with distinct basins of the Lake: northern (N), southeastern (SE) and southwestern (SW) basin (Fig. 1). Preliminary surveys were carried out to verify ease of access. During the monitoring period, water temperature ranged from 15.0 to 28.2 °C, the dissolved oxygen content was 7.9-11.0 mg l^{-1} and pH showed values between 6.9 and 8.8. Generally, substrate was a mixture of gravel, cobble and coarse sand, except in site 1, where cobble was absent, and site 2, where the bottom was composed of fine sand and mud. No submerged vegetation was observed and reed bed was present in sites 1, 2 and 3.

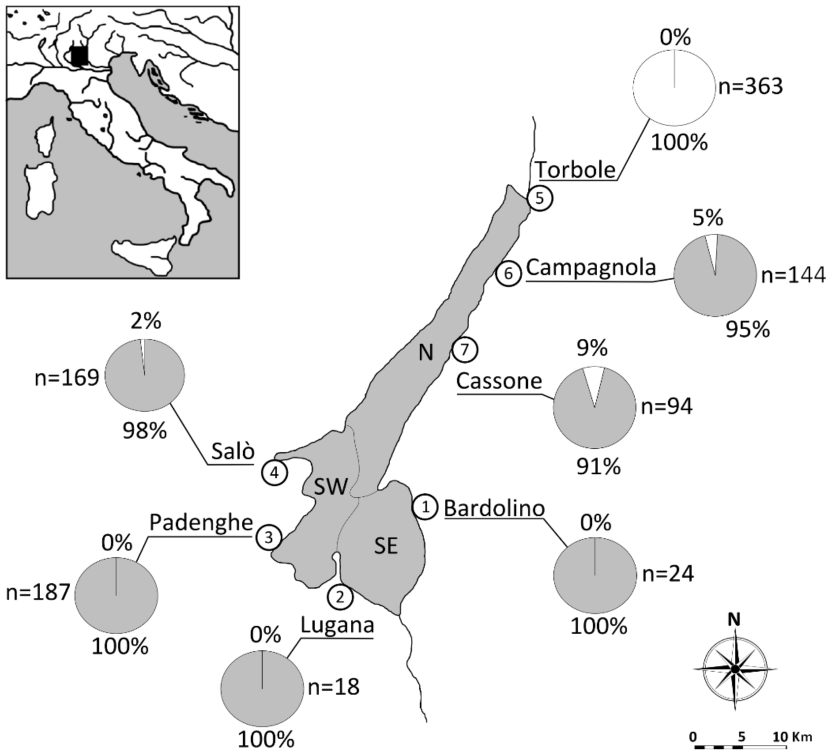

Fig. 1. Sampling sites of the littoral zone and presence of the two gammarid species during the monitoring period (grey= *Dikerogammarus villosus*; white= *Echinogammarus stammeri*).

Samplings in littoral zone were performed up to 3 m from the lake shore. Gammarids were collected by kick-sampling method (Barbour et al., 1999) employing a hand net with a mouth of 23 x 23 cm and a mesh size equal to 200 µm, which covers a squared area of 0.05 m^2. Three replicates were taken at each site (0.15 m^2 total sampling surface) and specimens were stored into 75% ethanol solution. In laboratory, individuals were sorted, identified and densities (ind m^{-2}; mean values ± S.D.) were calculated for each gammarid species.
Confrontation with the dataset provided by Casellato et al. (2006) was carried out for the three basins using the Wilcoxon non parametric test to check significant differences about densities and using the χ^2 test to check differences among percentage frequencies of the two species. All statistical confrontations were performed using STATISTICA 7.1 software.

Results

Occurrences of *Dikerogammarus villosus* and *Echinogammarus stammeri* at each sampling site are summarized in Figure 1. At every station *D. villosus* was the dominant gammarid species, except in the most northern (site 5) where it was absent. *E. stammeri* was not found in the SE basin and was weakly present in the southwestern, with few specimens observed in June in site 4. Contrariwise, the native was more abundant in the N basin and it was the only gammarid species in site 5.

Densities of *D. villosus* ranged from 0.0 to 160.0 ind m^{-2} in the SE basin, 66.7 to 1040.0 ind m^{-2} in the SW and 0.0 to 533.3 ind m^{-2} in the N basin. Differently, *E. stammeri* showed densities between 0.0 to 20.0 ind m^{-2} in the SW basin and between 0.0 to 2180.0 ind m^{-2} in the northern (Fig. 2).

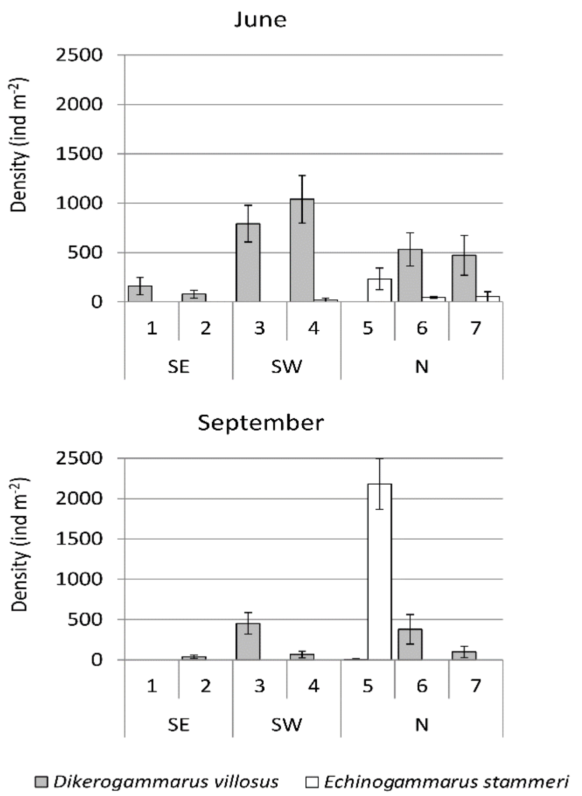

Fig. 2. Mean density and S.D. observed for *Dikerogammarus villosus* and *Echinogammarus stammeri* at each sampling site during the working period. Sites code are reported in Figure 1

Discussion

Our findings confirm that *Dikerogammarus villosus* is the more abundant gammarid in the littoral area of the SE and SW basins of Lake Garda. Indeed, occurrence of *D. villosus* are not significantly different from those observed at the same sites during the same sampling period by Casellato et al. (2006). Likewise, Wilcoxon test has not highlighted significant differences about densities of *D. villosus*, although our values seemed to be higher. Instead, significant differences from the previous observation were found in the N basin about the occurrence of *D. villosus* (χ^2=102.46, p<0,001) and about *Echinogammarus stammeri* (χ^2=10.07, p<0,01). No significant differences were found between past and present densities, even though in our samples values of *D. villosus* seem to be lower, values of *E. stammeri* seem to be higher and p-values tend to significance in both cases (Wilcoxon test, N=6: Z=1.78, p=0,07 for *D. villosus*; Z=1.82, p=0,07 for *E. stammeri*). However, this could be due to a different community development which occurs between the two monitoring periods. In fact, Casellato et al. (2006) shows how occurrence of *E. stammeri* was higher in northern than in southern basins considering a wider period of time.

Distributions of the two species in the littoral belt of the Lake Garda seem to be unchanged in the last ten years, even though there are some alarming findings about deeper environments. The “killer shrimp” was found earlier down to 11 m, where rare specimens were observed (Casellato et al. 2006). Furthermore, the lower limit of *D. villosus* seemed to be

5 m depth (Casellato et al., 2008). However, the concern that the invader is moving deeper could be confirmed by some findings both in sublittoral (17 m depth) and profundal (100 m depth) zone of the N basin (Tab. 1). This suspected presence could have a deep impact on the *E. stammeri* community with possible adverse effects resulting from niche overlaps.

Month	Location	Environment	Depth	*D. villosus*	*E. stammeri*
Mar	Torri del Benaco	Sublittoral	20		+
		Profundal	115		+
	Brenzone	Sublittoral	28		+
		Profundal	108		+
Sep	Torri del Benaco	Sublittoral	21		+
		Profundal	100		+
	Brenzone	Sublittoral	17	+	+
		Profundal	100	+	+

Tab. 1. Presence of *Dikerogammarus villosus* and *Echinogammarus stammeri* in two sampling stations of the northern basin. Data provided by ARPAV (2013).

Finally, the spreading of *D. villosus* has probably become slower in the last years in the littoral zone, but the situation at lower depths is not clear. Therefore, systematic monitoring campaigns over a long time period are necessary to check the dynamic of the invasion and the interaction between native and alien species.

Acknowledgements
We would like to thank undergraduates students Elisa Bertamè and Greta Baruffaldi for the help in sorting operations.

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Current status of *Sinanodonta woodiana* (Lea 1834) in Poland

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Keywords: distribution, biometry, growing rate, origin

Introduction

Spreading of alien species has become a common phenomenon observed by scientists all over the world. It results from many reasons including anthropogenic behaviors like human mobility and expansion. These alien species may often affect native species and change habitats and even ecosystems. In 2010 the EC published a document on an EU strategy for the protection of biodiversity by 2020 (European Commission, 2011). Invasive alien species have been therein recognized as one of the greatest direct threats to the European nature. In 2011 an order issued in Poland by the Ministry of Environment was published, dated on 9th September 2011, concerning the list of plants and animals of alien species which, if released to the environment, can threaten native species or natural habitats. Among 52 species, the Chinese mussel clam *Sinanodonta woodiana* (Lea, 1934) is also specified. The migration path of this species began in eastern and south-eastern Asia, and due to export of farmed fishes the Chinese pond mussel appeared in Europe and North America (Watters, 1997). In Europe it was first discovered in fish farms in Romania in 1979 (Sarkany-Kiss, 1986).

For several years the research targeted known populations of this species has been leading in Poland. The investigations on its spreading, the knowledge of its biology and the study about habitat characteristics determining its occurrence have become key tasks that allow predicting the consequences of its presence and finding ways which can limit its further migration. The first colonization traces (empty shells) of *S. woodiana* in Poland were reported by Bőhme (1998). The first stable population in Poland was recorded by Zdanowski (1996) who discovered it in reservoirs with water at elevated temperatures coming from the Konin power plant in western Poland. In 1992 it occurred that this clam can get settled even in basins of natural thermal regime (Urbańska et al., 2012). Each year brings new reports about the occurrence of the Chinese pond mussel in Poland (Andrzejewski et. al., 2013).

In this paper we summarize the current knowledge about the Polish population of the Chinese mussel clam. The goal of the paper is also to present identified conditions that facilitate the migration process of the Chinese pond mussel.

Materials and methods

New locations where *S. woodiana* occurs are still looking for using mainly field research but also a method of questionnaires and interviews with fish breeders and anglers that was deployed by the authors few years ago. The reservoirs are also controlled during their drainage done mainly in artificial ones from time to time due to operational reasons. Only in 2013 6 new locations were confirmed.

In addition to these reports about new locations, several types of research have been already conducted to learn the population of *S. woodiana* in Poland and its impact on the ecosystem. These include morphological characteristics, reproduction potential, habitat preferences, density indices, population distribution as well as variability at the genetic level. Natural enemies, parasites and symbionts of the Chinese pond mussel have been also analyzed. This alien species may have different growing rate at the beginning of the invasion. This may cause difficulties in age determination by analysis of growing rings. That is why sclerochronology method is preferred to evaluate the age of *S. woodiana*.

Results

Including literature survey and own research data at least 25 locations of the Chinese pond mussel have been confirmed in Poland. They are shown in **Fig. 1**.

Fig. 1. The prevalence of the Chinese pond mussel in Poland

A regular drainage of ponds that is done usually in the autumn and lasts till early spring may reduce the population size but certainly does not result in a permanent loss of population (Andrzejewski, 2013). Some *S. woodiana* specimens move along with the draining water and bury themselves in slimy pits near the drainage ditch, and some of them die due to overdrying, especially if they find no possibility of penetrating the sediments. It is an explanation why the thickness of sediment in a pond plays an important role in success of the settlement. ANOVA has shown that reservoir features that determine the clam habitat affect significantly mussel high to length ratio.

Multiple regression analysis reveals further conclusions related to factors that may affect the population grow. The results demonstrate that larger water reservoirs constitute better conditions for settlement. Older and longer mussels occur in deeper fish ponds. Moreover, southern ponds produce more biomass. The average age of mussels in a fish pond depends on type of bed and depth.

Collected data allow also concluding that the closer to the river inflow, the greater shells occur. Using sclerochronology for one of populations the growth rate occurred to decrease exponentially in time. The differences in weather conditions between consecutive years do not affect the differences in growth of the mussels.

Discussion

The *S. woodiana* population has expanded in Poland significantly and quickly for last years. There are more mussels in eastern Poland where the migration path of this species progresses from (Urbańska, 2012). It was confirmed by the comparative genetic outcomes (Soroka et al., 2014). Both fish farming records and molecular data supported by cluster analysis confirm that the origin of the population in Poland may be Hungary. The specimens of *S. woodiana* from Romania show a greater genetic variation (about 6%) as compared to European populations in Poland, Hungary, Ukraine and Italy. It may mean that there are at least two migration routes of the invasion spreading.

S. woodiana in Poland is mostly present in fish ponds but in other countries including Croatia, Italy and the Czech Republic (Andrzejewski, 2013) it occurs in lowland rivers, canals and wetlands. Dense vegetation constitutes a barrier for *S. woodiana* expansion and the reservoirs rich in nutrients are favorable. Pond depth is another factor that affects the mussels. They prefer shallow reservoirs with warmer water but they avoid the rocky bottoms and macroliths (Kraszewski et al., 2007). The larger pond and smaller number of drainages, the larger mussels are recorded. Cyanobacterial blooming has a small influence on the species (Du et al., 2011). Moreover it has occurred that low temperate of water does not restrict the reproduction. The Chinese pond mussel has a much higher tolerance of hypoxia and pollution than native species (Sîrbu et al., 2005). Greater shells are found closer to water sources flowed into lakes because water in such places ensures better oxygenation and carries more biomass that constitutes the foodstuff eaten by bivalves. Finally, these are human actions that contribute to spreading of the mussel clam. It results from transport of farmed fishes and even a commerce of specimens that are used by gardeners in their ponds to filter water. This species can threaten the native fauna. The spreading is observed so wide because the small selectivity of glochidia in selection of the host suppress some barberries in reproduction (Douda et al., 2012).

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Adaptive management of overgrown submerged macrophytes in the south basin of Lake Biwa

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Keywords: Lake Biwa, Mother Lake 21 Plan, Submerged Macrophytes, Adaptive Management of Ecosystems

Increase of submerged macrophytes in the south basin of Lake Biwa

Lake Biwa, the largest lake in Japan, is classified into two basins: the large (618 km^2) and deep (mean 43 m) north basin, and the small (52 km^2) and shallow (mean 4 m) south basin. Bivalves, especially an endemic freshwater clam *Corbicula sandai*, were abundant before the 1960s in the coastal area of Lake Biwa, especially in the south basin, but decreased rapidly in the last 50 years (Shiga Prefectural Fishery Experiment Station, 1954, 2005). A possible reason is expansion of muddy bottom area in the coastal area (General Investigation Committee of Living Things in Shiga Prefecture, 2011), due to decrease in sand inflow from the drainage basin by the development of erosion control in the forest and flood control in rivers. In addition, massive growth of submerged macrophytes, mainly domestic but also alien species, in recent years is considered as one of the most important factor in the south basin.

The distribution area and biomass (dry weight) of submerged macrophytes in the south basin were estimated as 27 km^2 and 3,940 t in 1936 (Yamaguchi, 1938; Ohtsuka et al., 2004; Haga et al., 2006b), respectively. After a severe drought in 1994, macrophytes began to increase and cover almost entire the south basin every summer from the 2000s, and reached 48.6 km^2 of the distribution area and 9,623 t of biomass in 2007 (Haga & Ishikawa, 2011).

Usually, moderate growth of submerged macrophytes provides spawning and breeding habitats for fish in the coastal area, especially for domestic crucian carps *Carassius* spp. in Lake Biwa (Hirai, 1970). However, the overgrown macrophytes off the coast cause nuisances in navigation and fishery as physical obstacles, and degradation of habitat for benthic animals due to the deterioration of dissolved oxygen on the bottom (Haga et al., 2006a).

Mother Lake 21 Plan and Macrophyte Control Team

To hand over sound Lake Biwa to the next generation, Shiga Prefecture settled on Mother Lake 21 Plan (Lake Biwa Comprehensive Preservation and Improvement Project; Shiga Prefecture, 2000). The plan based on the idea “symbiosis between Lake Biwa and the people living an active lifestyle” that was realized in the past. For example, in the 1930-1950s, submerged macrophytes were harvested actively in Lake Biwa to use as compost for rice paddy. In addition, dredge fishery of freshwater clams disturbed the sandy bottom so that mud and macrophytes were removed. As a result, macrophytes grew moderately and suitable habitats of bivalves were maintained.

Fig. 1. Harvesting of submerged macrophytes by fishermen using dredge in the south basin of Lake Biwa

Shiga Prefecture organized Macrophyte Control Team in 2010 to solve the problem caused by the overgrown macrophytes in the south basin and recover the ecosystem of Lake Biwa. Based on the results of scientific monitoring and researches, and experiences of fishermen, management plan of macrophytes have been discussed adaptively. Macrophytes are harvested mainly by fishermen using dredge following the management plan (Fig. 1). In addition, harvested macrophytes are used for compost as a series of the works in the Macrophyte Control Team.

Difficulties in adaptive management of submerged macrophytes and the ecosystem

As a scientific monitoring, we investigated relative biomass of submerged macrophytes and the density of benthic macroinvertebrates in May and August 2011-2013 at 9 sites in the south basin of Lake Biwa. To collect macrophytes as quantitative as possible, a barbed wire coiled around a steel bar (length: 50 cm) attached with adequate length of rope was thrown into the lake and pulled up. Collected Macrophytes, including filamentous algae, were sorted by species and measured dry weight to make comparisons among the sites, months and years. Benthic macroinvertebrates were collected at the same time of macrophyte collection using Ekman-Birge grab (15×15 cm^2), sieved through a 250 μm mesh net and sorted by taxa.

In 2011, submerged macrophytes were few in May, and then increased rapidly in August (Fig. 2). The most abundant species in August 2011 was *Potamogeton maackianus* (47.4%), followed by *Elodea nuttallii* (28.7%) and *Ceratophyllum demersum* (19.1%). Growth of macrophytes in May 2012 was similar to May 2011, but in August 2012, macrophyte biomass decreased to 25.6% of that in August 2011. Considering that water transparency from May to October 2012 was the lowest and chlorophyll *a* concentration in summer 2012 was the highest in the last 10 years in the south basin (Shiga Prefecture, 2013), turbid water mainly caused by massive occurrence of phytoplankton should prevented photosynthesis of macrophytes.

If the decrease of submerged macrophytes exceeded the threshold, a catastrophic shift from macrophyte to phytoplankton dominance might occur (Scheffer et al., 2001). Because the decrease in macrophyte biomass continued to May 2013 (Fig. 2), Macrophyte Control Team decided to suspend macrophyte harvesting until summer 2013. However, in August 2013, macrophytes overgrew again and the biomass reached 71.4% of that in August 2011. The most abundant species in August 2013 was *Hydrilla verticillata* (47.1%), followed by *C. demersum* (24.9%) and *P. maackianus* (14.4%).

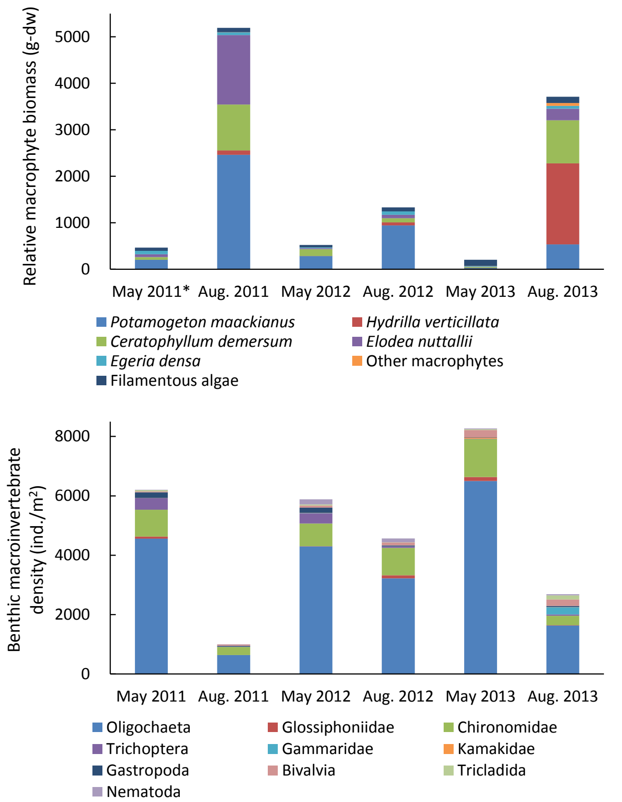

Fig. 2. Relative biomass of submerged macrophytes (upper) and mean densities of benthic macroinvertebrates (lower) from May 2011 to August 2013 at 9 monitoring sites in the south basin of Lake Biwa.
*Estimated from 7 out of 9 sites.

The monitoring of submerged macrophytes provides fundamental information for the management plan, but the methods to maintain moderate growth are not established due to scientific uncertainties in the prediction. However, if the harvesting is needed, we found that mean height of macrophyte communities decreased in winter by one-third harvesting effort needed in summer.

As to benthic macroinvertebrates, Oligochaeta are the most abundant group, followed by Chironomidae in 2011-2013 (Fig. 2). The relative macrophyte biomass showed significant negative correlations with the densities of total benthic macroinvertebrates (n = 27, R = -0.454, p = 0.017) and Oligochaeta (n = 27, R = -0.428, p = 0.026) in August 2011-2013. These results suggest that macrophyte harvesting is an effective method to improve the bottom habitat. However, because bivalves were few in the south basin, additional measures, e.g., improvement of substrate from mud to sand in the coastal area, should be needed to recover diversity and production of benthic macroinvertebrates. We continue trying to achieve successful management of the ecosystem of Lake Biwa.

Acknowledgements

We would like to thank Lake Biwa Policy Division, Shiga Prefectural Government, and Shiga-prefecture Federation of Fishermen's Co-operative Association for their cooperation in the macrophyte harvesting work to accommodate our scientific monitoring.

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Features of the eutrophication of largest freshwater lakes in the world

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Keywords: large lakes, eutrophication, water resources

Introduction

The problem of eutrophication of water bodies has been already relevant for more than a century. At present the majority of the world's lakes are affected by anthropogenic eutrophication. The most rapid eutrophication processes have taken place in shallow water bodies in both the tropical and temperate latitudinal zones. In tropical lakes they are intensified by consistently high temperatures, which accelerate biological processes. Eutrophication processes in deep lakes containing huge masses of water are mostly local and affect the shallow zone. The dynamic of changes in the trophic level of the largest lakes in the world, as well as changes in total volumes of water of different trophic categories for 1950-2010 are considered in the article. The largest lakes are the most important reserve of surface fresh water of the planet, so it is very important to have an understanding of the changes in the quality of this resource.

Materials and Methods

It is widely accepted that the world's largest lakes are bodies of water with a surface area of more than 1,000 km^2. In the world today there are 79 freshwater lakes with an area of 1,000 to 10,000 km^2 and 14 with an area of more than 10,000 km^2. It can be concluded from the total volumes calculated by Wetzel, 1983, that they are concentrated 4.6% and 70.6% of all fresh lake`s waters of the Earth, respectively.

The assessment of changes in the trophic status of the largest lakes in the world was carried out at the Institute of Limnology RAS [Rumjantsev et al., 2012, 2013]. It is based on the analysis of numerous literature data on the trophic status of the largest lakes. Scale characterizing the trophic status of lakes, includes categories of oligotrophic, mesotrophic, eutrophic, hypertrophic and transitional categories - oligotrophic-mesotrophic and eutrophic-mesotrophic. In the summation for each water body it was considered that the trophic status may varies both with area, and with depth.

Since artificial reservoirs, including the largest, are the most vulnerable to the process of eutrophication, for the territory of Russian Federation a comparison of the trophic status of largest lakes and reservoirs was made on the basis of literature data and government reports on the state and the environmental protection.

Results

At present the majority of the world's largest lakes, in one way or another, are affected by anthropogenic eutrophication. Fig. 1 shows the trophic status of the water masses (a), as well as the percentage ratio of the largest lakes with different trophic level (b).

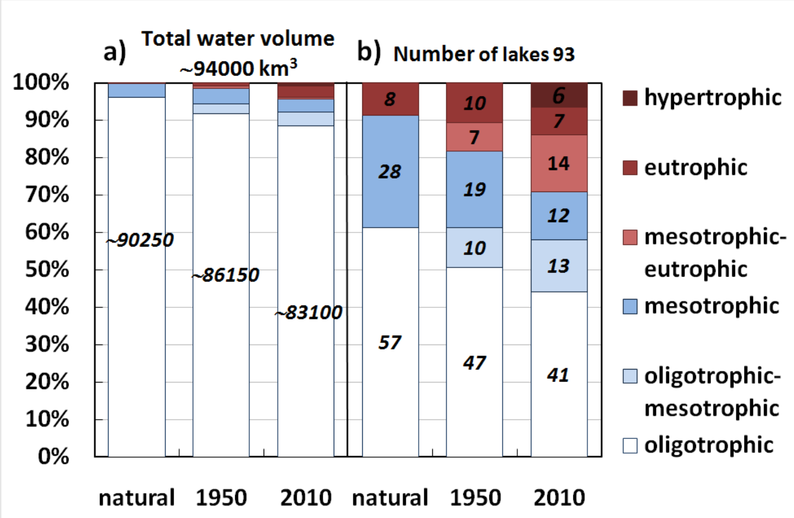

Fig. 1. The percentage ratio of water of different trophic categories in the largest lakes of the world (a) and the percentage ratio of lakes with different trophic status (b) for the levels of the 1950s and 2010s.

According to our estimates, under natural conditions about 96% of waters contained in 57 of the 93 world's largest freshwater lakes were oligotrophic. Due to human impact, by the beginning of the 21st century, only 41 lakes retained their oligotrophic status throughout their water area and 13 more lakes retained it in the deep water zone. For the period 1950-2010, oligotrophic waters volume decreased by 3.5%, and eutrophic and hypertrophic waters volume increased by 3.1%

The most rapid anthropogenic eutrophication processes have taken place in shallow water bodies in both the tropical and temperate latitudinal zones. Among the world's largest bodies of water, the following lakes acquired hypertrophic status due to anthropogenic impact by the beginning of the 21^{st} century: Chapala and Managua. Eutrophic-hypertrophic status was assigned to L. Tai and a part of L. Peipus. The following deeper lakes that are under significant anthropogenic pressures also acquired a hypertrophic status: Albert and Victoria. In the 1960-s-1970-s, L. Erie, the most shallow of the Great Lakes, acquired a eutrophic-hypertrophic status. Since the late 1970-s, its condition has begun to improve as a result of the actions taken by the US and Canadian governments. Anthropogenic eutrophication has also been observed in the shallow lakes Dongting and Poyang. However, since these lakes are located in the basin of Yangtze River, and are, therefore, bodies of flowing water, they remained mesotrophic in most of their water area despite the high population density and vigorous development of agriculture. A sharp increase in trophy was observed in the years of low water availability. Thus, a significant deterioration of water quality was reported in the 2000-s, which was associated with the completion of the construction works at the Three Gorges Dam upstream of the Yangtze River and the filling of a 22-km^3 reservoir.

Eutrophication processes in large deep lakes containing huge masses of water are mostly local and affect the shallow zone. A low level of anthropogenic eutrophication is observed not only in lakes whose catchment areas are relatively sparsely populated, but also on the deepest Great Lakes, where the deterioration process was quickly stopped by timely actions. A slight eutrophication affecting mainly the coastal area is observed in the deepest African Lakes—Tanganyika, Nyasa, and Kivu, which are characterized by a large population density in the

basins and almost no treatment of waste water. The huge masses of water and rapid selfpurification processes reduce the negative effects of human impact.
Since the bulk of fresh water is concentrated in the deepest lakes, the total amount of oligotrophic waters contained in the largest lakes remains quite large.
It should be noted that the waters contained in the largest artificial reservoirs are more susceptible to eutrophication. In a total volume of water contained in the 9 major lakes of the Russian Federation, the proportion of oligotrophic waters is more than 96%, at the same time in 19 major reservoirs - a little over 10%. Most reservoirs are filled by mesotrophic waters with significant signs of eutrophication (Fig. 2).

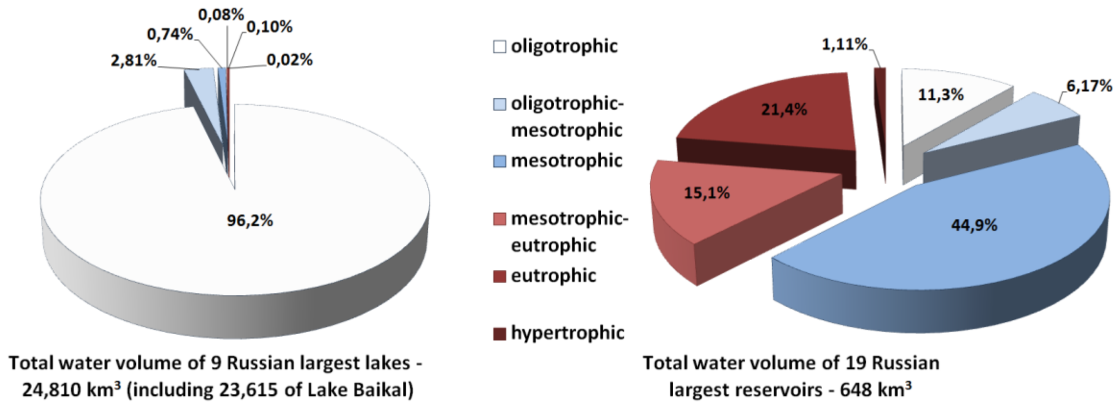

Fig. 2. The percentage of water of different trophic categories in total volume of water of largest lakes (a) and reservoirs (b) of Russian Federation

Discussion

Concerning the anthropogenic eutrophication of water bodies, it should be noted that the most severe consequences are observed in tropical countries, which are characterized by

- high temperatures, which facilitate the rapid development of biota;
- significant rainfall, which leads to high rates of nutrient leaching;
- high population density, which increases the anthropogenic pressure on natural resources;
- the absence of proper environmental legislation and institutions to respond to emerging issues in a timely manner;
- low level of economic development and the ensuing lack of funds for mitigation.

The most complex issue in the less developed countries appears to be the reduction of biogenic communal wastewater, which is especially dangerous and causes epidemics. The first prerequisite for effective action is the construction of sewage systems followed by communal wastewater treatment systems, which requires significant financial investment. Due to the endemic poverty, primitive housing, very high population growth, and lack of control and coordinated efforts of various organizations, sewage systems cannot be provided for the already built houses, not to mention the ever-emerging new settlements. Even if a country receives international funding aimed at the construction of sewage treatment systems, it usually cannot provide high-quality communal wastewater treatment. It must be recognized that the inflow of nutrients with communal wastewater in most African and some Asian countries is unlikely to be reduced in the near future.

The problem of reducing the nutrient load on water bodies located in the temperate zone is resolved more effectively, especially in advanced economies, but requires huge financial investment. Severe limitation of the nutrient inflow, which has become common practice since the 1970s-1980-s, along with strict compliance with regulations and legislation, is usually effective in improving the ecological status of lakes. However, even provided that the rehabilitation activities are successful, the reoligotrophication of a water body is a slow and complex process associated with unforeseen situations and periodic worsening of some of the trophicity indicators. The rate of this process depends not only on the scale of the undertaken measures but also on specific features of a given water body, i.e., its natural purification ability. Shallow and low-flowing water bodies demonstrate a delayed response to water conservation measures, which is due to the accumulation of large amounts of nutrients in the bottom sediments, which are then fed back into the water.

In conclusion, it should be noted that the largest lakes are the most important reserve of surface fresh waters. Emphasis should be placed to the maintenance of their ecological status.

Acknowlegments

Must express our gratitude to V.G. Drabkova, our co-author of the monograph "The Great Lakes are the world".

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Environmental Conditions and Eutrophication Status of Rawapening Lake of Central Java, Indonesia

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Keywords: Rawapening Lake, Indonesia, water hyacinth, eutrophication, sediment load, water quality, nutrient concentration

Introduction

Rawapening is one of 15 Indonesian lakes identified as national priority lakes for conservation. Naturally, Rawapening is a tectono-vulcanic lake. In the early 1900s the only lake outlet of Tuntang River was dammed for hydroelectricity, irrigation and fisheries (Suprobowati, 2012). The lake area varies seasonally from 2,700 ha (wet season) with depth of 463.9 m to 800 ha (dry season) with depth of 461.5 m. The maximum volume of water stored in the lake is 65 million m^3. Lake receives water from the springs on the mountains side and from eight tributaries (UNEP, 1999). The lake has been facing eutorphication problem indicated by invasive macrophyte coverage of water hyacinth over 40 % of the lake surface area (UNEP, 1999). Intensively used of catchment area for development of urban and agriculture area has increased nutrient concentration and sediment load to the lake which stimulate eutrophication process. The eutrophication problem has caused water quality degradation of lake and reduced its carrying capacity and lost its ecosystem service such as water supply, recreation, and fishing activity. The study was aimed to examine the current environmental conditions and eutrophication status in Rawapening Lake.

Materials and methods

Sediment load, water quality, and nutrient concentration were measured in the tributaries of lake inflow, the lake water and the lake outflow of Tuntang River. The observation and the water sampling were conducted in May 2013, in addition, the observations of water quality and nutrient loading in lake water were also conducted in May, June, July, August and November 2013 at four stations. The water samples were taken at the surface and at secchi depth (Fig. 1). Sediment load and the total suspended solids (TSS) were measured from discharge of lake inflow. Water quality measurements included temperature, pH, turbidity, conductivity, dissolved oxygen (DO), total suspended solids (TSS) and secchi septh (SD). The measurements were conducted by using the Water Quality Checker (WQC, Horiba U). TSS was analyzed in the laboratory by using gravimetric method. Water samples for measurements of the total nitrogen, nitrate, total phosphorus, orthophoshpate and clorophyll-a concentrations were preserved and analyzed in the laboratory according to the Standard Method by Grinberg *et al.* (1992).

Results

Total sediment load into Rawapening Lake was around 10.42 million kg.year^{-1}, while the sediment load exit from the lake was approximately 3.16 million kg.year^{-1} (Table 1). Same observation perceived in the nutrient concentration where higher nutrient concentration found in the tributaries of lake inflow and in the lake water than those in the lake outflow (Table 1). These conditions indicate that the lake acts as a sink of sediment and nutrient discharged from the tributaries. DO concentrations in the tributaries of lake inflow ranged from 3.75 to 7.85 mgL^{-1} , while DO concentration in the lake outflow was 3.4 mgL^{-1}. In the lake water, DO fluctuated spatially and temporally from 1.72 to 11.5 mgL^{-1} with the average values ranged from 4.15 to 6.23 mg/L. Temperature in the tributaries of lake inflow and outflow ranged from 23.43 to 26.44 ^{o}C, while the temperature in the lake water ranged from 26.4 to 27.7 ^{o}C. The values of pH in the tributaries of lake inflow and outflow ranged from 7.35 to 7.95, while in the lake water ranged from 7.09 to 7.70. Turbidity and conductivity in the tributaries of lake inflow and outflow were 13.4-117.0 NTU; 19.45 NTU and 0.138-0.240 mS/cm; 0.163 NTU mS/cm respectively. The average values of TN, nitrate, TP, orthophosphate concentrations in lake water ranged from 0.084 to 1.467 mg.L^{-1}; 0.053 to 1.004 mg.L^{-1}; 0.036 to 0.178 mg.L^{-1}; and 0.009 to 0.073 mg.L^{-1} respectively. The concentration of chlorophyll-a in lake water ranged from 9.982 to 25.42 µg.L^{-1}. Based on the trophic status index (TSI) calculation by Carlson and Simpson (1996), Lake Rawapening was classified eutrophic (Fig. 2). TSI(P) greater or equal to TSI (SD) value but higher than TSI(Chl) value indicated that Lake Rawpening was dominated by non algal particulates. Higher TSI(TP) value than TSI (Chl) value and low TN:TP indicated that the lake was phosphorus surplus and nitrogen limitation. The results suggest that phosphorus is a major factor causing the eutrophiction by invasive macrophyte coverage and not by alga bloom in Lake Rawapening.

Discussion

Intensively used of catchment for development urban and agriculture area was identified as a factor that stimulate the eutrophication process and sedimentation in Lake Rawapening (Subrobowati *et al.*, 2012). Domination of unirrigated agriculture area in the catchment used for vegetable cultivation has potential erosion causing sedimentation in Lake Rawapening (Wuryanta & Paimin, 2012). The tributaries of lake inflow which receive run-off from agriculture and the human settlements contribute high sediment load to the lake (3.7 – 5.3million kg.year^{-1}). Eutrophication in Rawapening indicated by high biomass of macrophytes may have high organic matter deposits in the lake bottom. Decomposition of this organic material can cause depletion of desolved oxygen (DO) in the lake water and outflow. It is apparent that eutrophication condition in Rawapening causes degradation of water quality especially DO in lake water and exit from the lake. Surplus of phosphorus and nitrogen limitation is common in lake such as Lake Rawapening where the sorounding area is the mountainous area with critical catchment that has potential soil erosion. The erosion usually carries solids dominated by clay containing phosphate adsorbed to it. The nitrogen limitation is expected due to uptake by alga growth or aquatic macrophyte (Goldman & Horne, 1983). Eutrophic condition of lake with excessive macrophytes usually caused by internal loading of phosphorus released from the organic material rich sediments (Wetzel 2001). Phosphorus internal loading released from the organic material rich sediments might contribute to surplus phosphorous in lake water of Lake Rawapening.

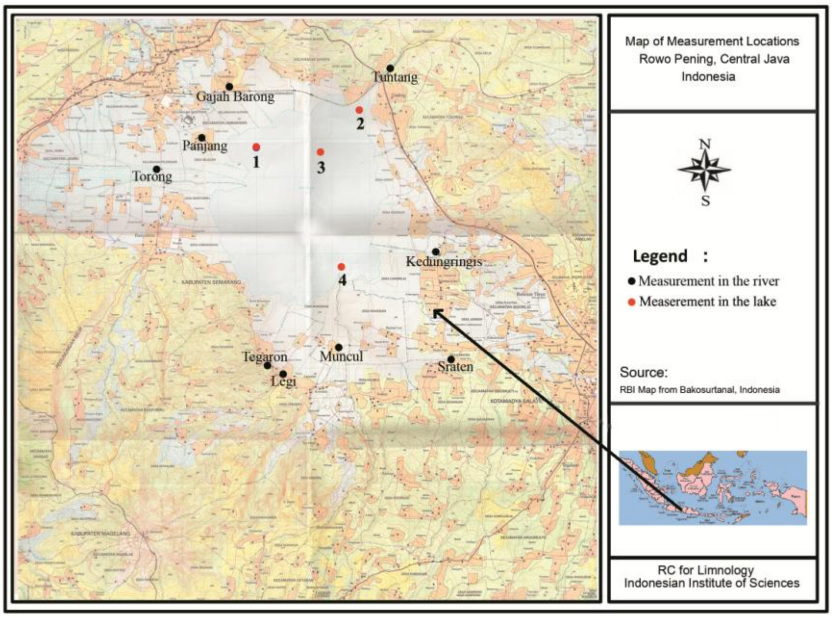

Fig. 1. Map of sampling locations

Parameters	Lake water	Sampling site inlet 1	inlet 2	inlet 3	inlet 4	inlet 5	inlet 6	inlet 7	outlet
Discharge (m.second^{-1})		3.12	2.68	2.12	0.99	0.64	0.24	0.1	40.1
Sediment load (Million kg.year^{-1})		3.73	5.36	0.53	0.12	0.34	0.25	0.05	3.16
Secchi depth (m)	0.63-0.95								
Chlorophyll (µg^{-L})	9.98-25.42								
Turbidity (NTU)	9.0-38.7	117	52.9	13.4	20.65	71.5	104	49.7	19.45
TSS (mg^{-L})	4.2-17.1	38	63.5	8	4	17	34	17	2.5
Conductivity (mS/cm)	0.170-0.261	0.18	0.138	0.206	0.24	0.233	0.287	0.177	0.163
Temperature (^{o}C)	26.4-27.1	23.6	25.48	24.6	24.14	25.2	23.43	23.81	26.44
DO (mg^{-L})	4.15-6.23	7.65	3.75	7.58	7.41	7.85	7.3	7.54	3.24
pH	7.09 -7.70	7.6	7.49	7.35	7.45	7.95	7.73	7.61	7.5
TN (mg^{-L})	0.084-1.467	1.64	1.14	1.905	3.509	3.246	2.068	1.003	0.456
N-NO$_3$ (mg^{-L})	0.053-1.004	1.37	0.98	1.652	3.177	2.646	1.805	0.76	0.375
TP (mg^{-L})	0.036-0.178	0.22	0.14	0.177	0.179	0.169	0.179	0.22	0.082
P-PO$_4$ (mg^{-L})	0.009-0.073	0.07	0.05	0.091	0.074	0.077	0.098	0.1	0.011

inlet 1: Panjang; inlet2: Torong; inlet3: Muncul; inlet4:Sraten; inlet5: kedungringis;Inlet6: Gajahbarong; inlet7: Gajahbarong; outlet: Tuntang.

Table 1. Sediment load , water quality and nutrient concentartion in the lake inflow, the lake water and the lake outflow

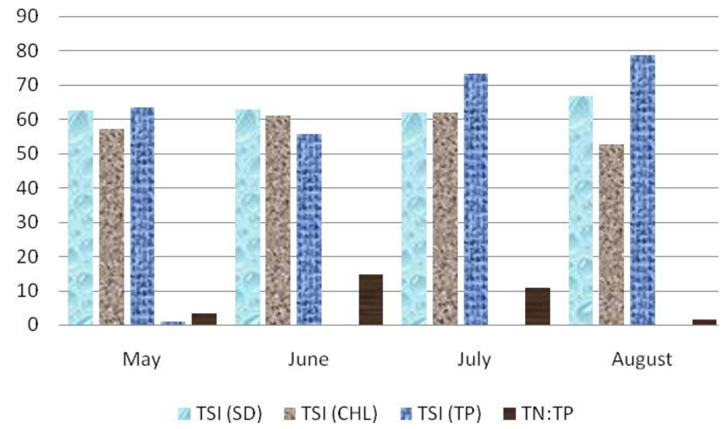

Fig. 2. Trophic State Index and TN:TP ratio of Rawapening Lake

Higher input of sediment and nutrient concentration from lake inflow than those of lake outflow has caused sedimentation and stimulated eutrophication in Lake Rawapening. Eutrophication problem has caused degradation of of water quality in the lake water and the lake ouflow water. Lake Rawapening is classified hipereutrophic with conditions of phosphorus surplus and nitrogen limitation. Phosphorus is apparently a major factor causing the eutrophication by invasive macrophyte coverage in Rawapening lake. Reducing the the sediment and phosphorus loading to the lakes by managing cacthment area and nutrient input to the lake and by controlling invasive macrophyte coverege reduce eutrophication problems in Lake Rawapening.

Acknowledgements
This study is supported by Research Centre for Limnology, Indonesian Institute of Science, through DIPA research project. Many thanks to Ms Wekas from Department of Husbandry and Fisheries Ungaran, Semarang, Central Java, Hazan Fauzi, Rosidah and Dian Octaviani from Research Centre for Limnology , Indonesian Institutes of Sciences for helping in field work and samples analysis in the laboratory.

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LAKE PROCESSES AND DYNAMICS

Low-molecular organic compounds in fresh waters of the Leningrad Region

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Keywords: Leningrad region, dissolved organic matter (DOM) in water, low-molecular organic compounds, production, destruction.

Introduction

The analysis of organic matter regime in fresh waters is required for constructing the theory of aquatic ecosystems functioning, since the organic compounds determine specific features of natural waters and are largely involved in the metabolism of hydrobionts. For the practical purposes, data on concentration and composition of organic compounds are important in determining self-purification capacity of water bodies, their pollution indices and water quality criteria, as well as in environmental engineering of maximum permissible loads on the aquatic ecosystems. There are a limited number of studies on dissolved organic matter (DOM) in different-type lakes and rivers ((Molinero, Burke, 2009; Rizhinashvili, 2008), which consider the presence of individual substances. They are chiefly devoted to humic and fulvic substances in water (see, for example, Wetzel, 1992). Such situation seems inadequate, because we can not conclude on the DOM origin (either autochthonous, or allochthonous) against the lack of knowledge on its chemical nature and, therefore, are unable to provide an objective estimation of anthropogenic pollution and the trophic status of water bodies. In our opinion, low-molecular organic compounds are more informative to DOM research (Khaylov, 1971; Ittekkot et al., 1981).

Therefore, the aim of our study is to define the quantitative and qualitative composition of the low-molecular organic compounds in water samples collected from lakes and rivers of the Leningrad Region (mainly, the Karelian Isthmus area), in order to evaluate the production/destruction ratio in these ecosystems.

Materials and methods

Water samples were collected from May till mid-September 2012, in water bodies situated mainly at the Karelian Isthmus, Leningrad region, as follows. The lakes Troitskoye, Yushkelovskoye, Lebedinoye are small water bodies with the area of approximately 0.2–0.3 km^2 (Troitskoye, Yushkelovskoye) and about 2 km^2 (Lebedinoye). The Lembolovskoye Lake is larger; its area is 13 km^2. The average depth of these lakes varies in the range of 2–4 m (the depth of the Lebedinoye Lake is unknown). All the lakes and rivers around Vaskelovo refer to the Ladoga Lake basin. The Lebedinoye Lake is located in the Gulf of Finland basin. Because explored lakes and rivers are situated within settlement and forest territories, these water bodies are not exposed to severe pollution. Samples were taken from the surface water layer (0–1 m) in the near-shore sites of the above listed water bodies .

Gas chromatography-mass spectrometry (GC-MS) method was selected for our analysis, being one of the most precise and advanced methods for identifying low-molecular organic matter (Halket et al., 2005).

Results

Upon the analysis of chromatograms, above 30 substances were identified in the water bodies under study. These refer to the following classes: polyatomic alcohols (glycerine), aminoacids (proline), carboxylic acids (lactic, acetic, malic, citric, succinic, oxalic, ribonic, gluconic, and ketogluconic), monosaccharides (arabinose, ribose, xylose, galactose, lyxose, glucose, mannose, fructose, talose, and hexopyranose), disaccharides (maltose, melibiose, and turanose), monosaccharide derivatives (levoglucosan, mannitol, ribitol, arabinitol, and erithritol). In addition, phosphoric acid and urea were registered in samples. Notably, organic compounds were not found in the Lembolovskoye Lake sample, despite the fact of water «bloom», which occurred prior to sampling.

The occurrence and concentration of the above listed compounds is not uniform within the studied water bodies. With regard to carbohydrates, the xylose is present almost everywhere. The glucose was also registered in most samples; however, its concentration fluctuates in a wider range, as compared with that of the xylose. Same as the xylose, the glucose makes the major compound of diatoms, green and yellow-green algae (Barashkov, 1972). According to the data of J.H. Rich, H.W. Ducklow, D.L. Kirchman (1996), glucose also was predominant in ocean waters. Since the glucose and the xylose may be linked in metabolic processes, the evaluation of their ratio in water samples presents special interest. According to our calculations, the xylose/glucose ratio varies within quite a broad range, from 0.0018 (Troitskoye Lake, autumn) to 5.5 (Kuzminka River).

Fructose was registered in most water bodies under study, either together with glucose, or in the absence of the latter. The glucose/fructose ratio tends to certain constancy: its value made 3.07–4.65 in four water bodies (out of six, where such calculations were feasible). Among the other monosaccharides, the arabinose was found in the majority of water-bodies, in widely diverse concentrations. Computed ratio of pentoses/hexoses total concentrations ranges within 0.0018–3.40 and demonstrates the prevalence of pentoses over hexoses in approximately 50% of the total cases. Notably, all identified disaccharides were found only in autumn samples from the Troitskoye Lake and Vyun River. Pentoses in these samples are either absent or occur insignificantly.

Organic acids were not found universally across the studied lakes and rivers. Acetic and lactic acids, for example, occurred in three water bodies only, with close acetic-to-lactic acid molar ratio (5.99–7.92) in Yushkelovskoye Lake and Kivioja River.

The described pattern of predominantly “carbohydrate” composition of low-molecular organic compounds in natural fresh waters indicates, with high probability, the autochthonous genesis of DOM in the water bodies under study.

A weak though distinct trend of declining the pentoses/hexoses ratio, against the increasing total carbohydrates content, is noted in all studied water bodies (Fig. 1). In other words, hexoses are more often dominant at high carbohydrate concentrations, whereas pentoses dominate at low-level total carbohydrates. In the latter case, intensive destruction processes are suggested to occur. These processes may take form of hydrolytic splitting of polysaccharides (e.g., pentosans), or different pathways of respiration (under the Krebs cycle, or PPR) and fermentation. The high pentoses content (absolute and relative) is often accompanied by the presence of phosphates.

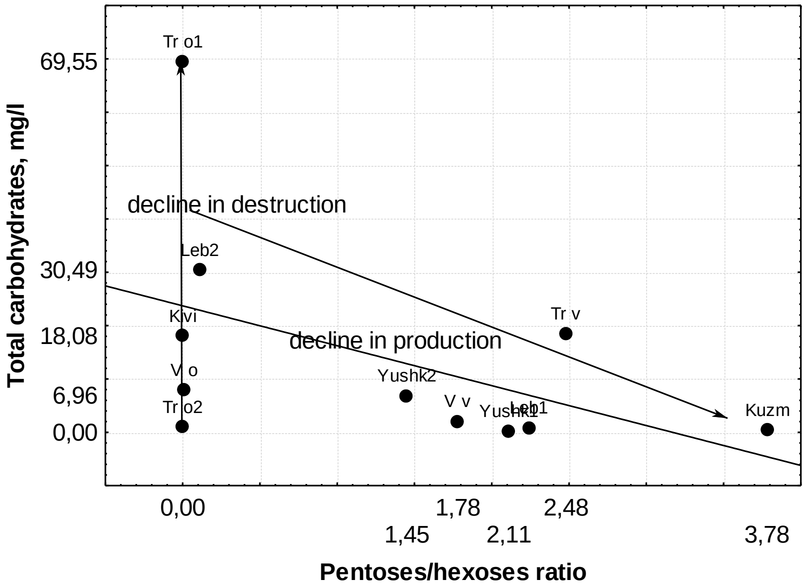

Fig. 1. Interrelation between the total carbohydrate concentration and the concentration ratio of pentatomic and hexatomic monosaccharides in the studied rivers and lakes. Explanations are provided in the text. Abbreviations for water bodies: Leb1, Leb2 — Lebedinoye Lake (sampling sites 1 and 2); Kuzm — Kuzminka River; Yushk1, Yushk2 — Yushkelovskoye Lake (sampling sites 1 and 2); Kivi — Kivioya River; Tr v — Troitskoye Lake (spring); Tr l1 and Tr l2 — Troitskoye Lake (summer, sampling sites 1 and 2); Tr o1, Tr o2 — Troitskoye Lake (autumn, sampling sites 1 and 2); V v — Vyun River (spring); V l — Vyun River (summer); V o — Vyun River (autumn)

Discussion

We can assess, to a certain extent, the specifics of production and destruction processes in water bodies (Fig. 1). In two-parametric system including the total carbohydrate content (the first variable) and the pentoses/hexoses ratio (the second variable), we assume the following pattern. When the values of the former decline and the values of the latter increase, the production rate decreases, whereas the destruction rate becomes considerably stronger. In this direction, the xylose/glucose ratio increases notably. We should add here that the xylose, unlike other pentoses (the arabinose and, especially, the ribose), seems to be highly resistant to bacterial utilization (Artemjev, 1974). The destruction rate decreases along with the growth of the carbohydrate content, in almost complete absence of the pentoses. Thus, considering the position of a water body in the space of two variables (carbohydrates and pentoses/hexoses), we can estimate the levels of production and destruction for certain water bodies and their sites.

In accordance with the above trend, such parameters, as carbohydrate concentration and the pentoses/hexoses ratio are recommended for the production/ destruction ratio estimations in the aquatic ecosystems. In turn, such estimations may be taken as a background for evaluating the level of ecosystem vulnerability to human impacts. It is important that our results are needed for elaboration of the natural water quality criteria and in the programs for water resources management.

The data obtained provide supporting material for the elaboration of water bodies' typology.

The elucidation of relationships between DOM composition, energy balance in ecosystems, and morphometric and hydrological characteristics of lakes, with regard to the level of anthropogenic impact is the objective of our further investigations.

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Water quality Assessment by Telemetry in a lake environment: collecting, modeling and representing data

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Keywords: lake environment, pollutant, CFD, aquatic robotic vehicle

Introduction

Under the background of climate change and human activities, there has been an increase both in the frequency of extreme hydrological events and the range of their impacts.

The hydrological extreme events can affect heavily the quality of water systems, leading to a critical condition, as shown in studies on laws of generation, transfer, transformation and degradation of pollutants. In this context, developing a model to couple hydrological inputs (such as heavy rains) with flow simulation and pollutant concentrations routing will aid the development of mitigation strategies.

The aim of this work is to identify contaminants in vulnerable surface water systems like lakes and reservoirs, their evolution and to assess management measures to mitigate their effects.

Monitoring, protecting, and improving the quality of water is critical for targeting conservation efforts and improving the quality of the environment. The standard traditional mapping and monitoring techniques have already become too expensive compared with the information achieved for environmental use.

Sustainable management of freshwater resources has gained importance at regional and global scales, and 'Integrated Water Resources Management' has become the corresponding scientific paradigm. Water resources, both in terms of quantity and quality, are critically influenced by human activity, including agriculture and land-use change, construction and management of reservoirs, pollutant emissions, and water and wastewater treatment.

Many methods to sample and investigate aquatic ecosystems have been developed and large amounts of data are being generated.

Traditional water quality monitoring typically involves costly and time consuming in-situ boat surveys in which in situ measurements or water samples are collected and returned to laboratory for testing of water quality indicators e.g. chlorophyll-a (indicator of algae) and suspended solids. This method allows accurate measurements within a water body but only at discrete points, they can't give the real-time spatial overview that is necessary for the global assessment and monitoring of water quality, (Peng et al., 2009).

The challenge of water-quality management associated with the principle of sustainable development has been of concern to many researchers and managers in the last decade. A variety of models have been developed for supporting missions of water-quality management.

Technologies are becoming more and more important for water-quality management, due to the rapid development of computational problem-solving tools and the enhancement of scientific approaches for information support.

In this context, the proposed research aims to define innovative methods for sampling, modeling, analyzing and representing pollution data in water bodies.

Materials and methods

The undergoing research is based on three activities: experimental water pollution data acquisition, mathematical modeling of their evolution and dispersion, and citizenship collaboration involvement.

For the dynamic acquisition of water surface data, a prototype ARV (Aquatic Robotic Vehicle) is being designed in order to sample the water surface quality parameters and to detect the presence of freshwater contaminants.

The technology is inspired by a previous experience made by Polytechnic University of New York in Hudson River (Atlantis website), with the design and development of a low-cost, self-sustained mobile surface vehicle for environmental monitoring. This device can be equipped with instruments for physical and chemical parameters sampling: pH, temperature, conductivity and dissolved oxygen, and can take pictures both below and above the water level. A sampler is added to detect the presence of freshwater anthropogenic-related contaminants: metals (mercury, lead), niters and nitrites, benzene, *e. coli* , pharmaceuticals and so on. The measurement of hydraulic quantities, such as velocity and water stage levels, is also needed for the second step and the robot will be equipped with specific devices for aimed at this.

To identify the changing conditions for the flow dispersion model, a preliminary hydrological study of runoff must be performed. The fluid dynamic simulation will be carried on by using the so-called Lattice Boltzmann Method (LBM), an alternative numerical fluiddynamics scheme based on Boltzmann's kinetic equation (Benzi et al., 1992) that represents flow dynamics at macroscopic level by incorporating a microscopic kinetic approach, preserving the conservation law (Ubertini et al,. 2010).

In LBM fluid is seen as composed by particles that can move and collide (mesoscopic approach) rather than a continuum medium as in the classical approach of the Navier-Stokes equations. LBM treats the water mass by analysing its particle distribution function, $f_i(\mathbf{x}, \mathbf{c_i}, t)$, at the site x and time t, moving with speed c_i. The dynamics of $f_i(\mathbf{x}, \mathbf{c_i}, t)$ is described with a discrete lattice Boltzmann equation, representing the evolution in time of the fluid flow by providing a numerical solution of the function evolution:

$$f_i(\mathbf{x} + \mathbf{c_i}\Delta t, t + \Delta t) - f_i(\mathbf{x}, t) + \Delta t \cdot \mathbf{F_i} = C_i(\mathbf{x}, t) = -\frac{\Delta t}{\tau}\left[f_i(\mathbf{x}, t) - f_i^{eq}(\mathbf{x}, t)\right] \quad i = 1, ..., b \tag{1}$$

where the left term is the molecular free-streaming and $C_i(\mathbf{x}, t)$ represents the particle collisions implemented with the Bhatnagar-Gross-Krook model (BGK), which relates the density evolution caused by collisions to dynamic modifications from local equilibrium f_i^{eq} (Chen et al., 1998).

The LBM model is adapted to free-surface simulations and pollutants transport, adding a multiphase approach (e.g. water and air) and a diffusion model .

The simulation of immiscible fluids is done through a Volume of Fluid (VOF) method that allows tracing the position of the interface between the fluids of interest. For our specific purposes, the interface is treated as a zero-thickness mathematical surface, across which the density field jumps from the light to the dense phase and viceversa, and is tracked throughout the computational domain through an additional scalar variable (i.e. liquid mass fraction)(Biscarini et al., 2013). A single set of LB equations is solved for both the heavy and light fluids (i.e. gas) in agreement with the front-tracking methodology, which requires no description of the physics of the phase-transition between the two phases.
As results of the LBM simulation, we can describe the complete evolution of flow field in terms of velocity, pressure, density and interface position.
The pollutants transport is simulated through a scalar transport advection diffusion model based on the general equation:

$$\frac{\partial k}{\partial t} = \nabla \cdot (D \nabla k) - \nabla \cdot (\vec{v} k) + R \qquad (2)$$

Where k is the generic pollutant concentration, D is the diffusivity, $\vec{v}$ is the average quantity velocity. R describes "sources" or "sinks" of the quantity c.

Results

The coupled hydrological-fluid dynamics model is an important instrument for evaluation of potential critical situations in water quality. It represents the base for decision-making process in case of floods, droughts or other critical events depending on the climate changing conditions.
The current development of CFD turbulence models and free surface computing methods (wave produced from the craft) allow evaluating performances in “calm waters”. It allows comparing these values with those gathered in the towing tank. The approach has the advantage of a real size simulation and a better control of the test conditions (velocity and viscosity of the fluid). This directly relates to an improved comprehension of the phenomenon thanks to the peculiarity of the CFD simulation that allows a simple fluid visualization.
The active participation of citizens in measurement collections and dissemination of results is essential: obtained results will be shown in a web-based GIS environment (Figure 1).

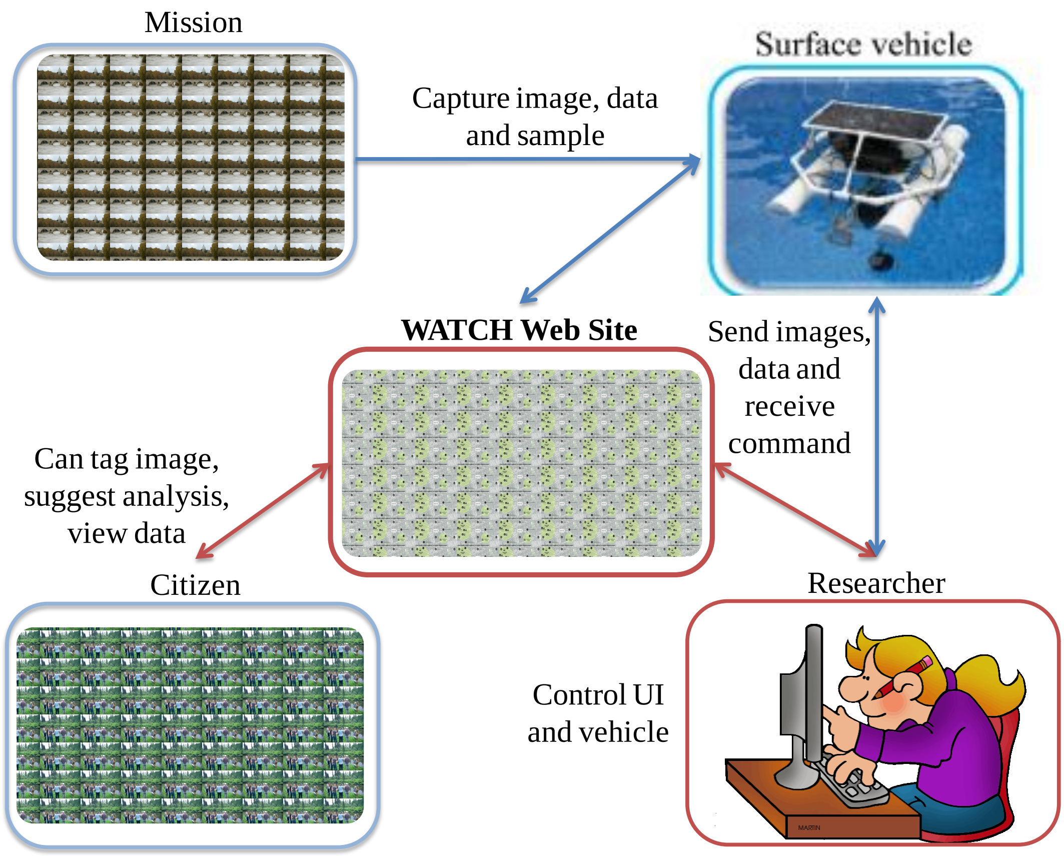

Fig. 1. Project elements

Discussion

This work focuses on climate change conditions and human activities influences that have led to an increase of extreme hydrological events both in frequency and range of their impacts.

Floods and flooding often result in widespread contamination that poses both immediate and long-term threats to human health and environment. The environmental consequences of flooding, however, can be extremely complex and difficult to assess due to their large spatial extent, multiple sources, sinks, and types of pollutants, and potential effects on nearly all the environment components.

On the other side droughts may give rise to a series of resources, environmental and ecological effects, i.e. water shortage, water quality deterioration as well as the decrease in the diversity of aquatic organisms.

Particular attention is posed in analyzing the interaction between external causes (e.g. climate change, punctual sources) and quality parameters of water, in order to define critical situations and mitigation strategies to be undertaken.

The proposed methodology allows creating and validating a practical tool for sampling, modeling, analyzing and representing pollution data in water bodies, through the synergic action of industries and scientific centers. Moreover citizens will be involved as “Scientific contributors”, interacting with a web-site, providing photos, data and suggestions.

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On the role of Hydrological balancing in lake basin management

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Keywords: water budget, Bolsena Lake, hydrogeological modeling

Introduction

Management of water resources in complex environmental systems including lakes or reservoir, requires advanced hydrological modelling to forecast main state parameters (levels, volumes, temperature, pollution level, …) and impacts of human activities on the natural context. In this work an opensource computational model is applied and tested in a typical Italian lake environment, the Bolsena lake, where surface flows, deep flows, direct losses from the lake surface, the lake regulation volume, and anthropic uses (drawing from and discharging into the lake) are jointly involved .

Bolsena Lake, located in northern Lazio, the largest volcanic lake in Europe, is a source of both environmental and economic wealth for the neighboring area, drawing tourists and providing drinking and irrigation water. Recently the system's hydraulic state has undergone moments of unbalance, due to the alternation of drought and flood periods starting in the early 1990s which have led to not negligible consequences from hydrological (decreased flow of some springs in the hydrogeological basin and toward the outlet, inundation of facing villages) and societal point of views.

The complexity of the hydrogeological and anthropic system and the current technical/scientific relevance of the latest water emergencies occurring at the lake, put in evidence the need of a solid plan to manage all different extreme scenarios that can affect the lake basin.

Therefore an instrument of basin/lake and lake/river management and simulation is necessary for mitigating the extreme values of the levels and flows and for controlling lake water quality.

Materials and methods

Lake Bolsena is situated in northern Lazio in a volcano-tectonic depression. It is the largest volcanic lake in Europe and the fifth largest in Italy. It has an elliptical shape, an area of 114.5 km^2 with a maximum depth of 151 m and a perimeter of 43 km; two islands emerge, Bisentina and Martana. It has numerous tributaries and a single outlet, the Marta river, that flows towards the Tyrrhenian Sea. It represents a great richness, from an environmental and economical perspective. In fact, it is used both as a tourist resource and as a source for drinking water and irrigation supply.

The hydrogeologic framework of the region (Baldi et al., 1974, Boni et al., 1986, Pagano et al., 1999) can then be schematized in the following way:

a large shallow aquifer of the volcanic layer, with thickness varying from a few meters to several hundred meters, characterized by continuous circulation;

a "waterproof" substrate of sedimentary formations and flysch formations that separate the volcanic aquifer from a deeper aquifer of carbonate soils of the Tuscan and Umbrian series.

The Marta river output from the Lake, in the absence of an instrument recorder, have been estimated on the basis of the known lake levels .The study area is equipped with various hydro-meteorological stations: for the continuity and temporal extent of the recordings the stations Bolsena (rainfall and temperature), San Lorenzo Nuovo and Valentano (rainfall) were considered.

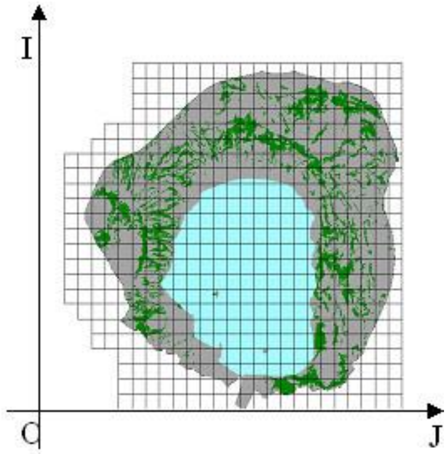

Fig. 1. Discretization of the basin of Bolsena Lake

The schematic representation of the catchment area is through its division into main cells and secondary cells.

Lake Bolsena has the peculiarity of having a catchment area much larger than the watershed. To account for this difference, we used a pool of extension of 375 km^2:. assigned a reference system matrix and overlaid with a grid mesh of 1 km^2, led to the division of the main basin in 421 cells (Figure 1).

The input data required to run the simulation are:

a) physiographic data: for each cell the height above sea level of the node Southwest, the percentage of area occupied by forests, swamps and lakes, the number of partial square, their surface and the direction of flow.

b) basin data: the name of the main hydrometric station, its position in the reference OIJ and the surface of the basin.

c) hydrometeorological data: the maximum and minimum temperatures (tenths of ° C), precipitation (tenths of mm), daily lake levels (m), the outflow from the lake (m^3/sec).

d) Basic and various options of the model, determined a priori: the time of concentration of the basin ZN, the correction coefficients of rainfall and temperature, the parameters governing the evapotranspiration, the percentage of impermeable surface.

Parameter	Value
Average observed level	304.26 m a. s.l.
Simulated average level	304.23 m a. s.l..
Average error	6.8 cm
Maximum error	25 cm
Nash Index	0.72

Table 1. Calibration results

Results

The model was applied to simulate lake levels at Marta hydrometric station and to compared the simulated with the observed data. the model was calibrated using the daily period 1Agosto 1999-1 August 2003, characterized by an increased reliability of the input data. Table 1 summarizes the main numerical values obtained.

Discussion

The results achieved with the model application have proved satisfactory in terms of average error on the estimation of the levels. The average error in the simulation is in line with those obtained from other models (Dragoni et al, 2003).

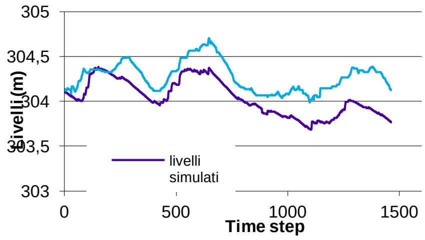

Fig. 2. Five years scenario

The coefficients calibrated can be a good starting point for setting an optimal management of the water resource. A possible application, in fact, may be to simulate scenarios with management rules (wells and withdrawals concessions, releases on Marta) and meteorological conditions different from the present, simulating the effect they produce on the lake in terms of levels. In figure 2 is shown a simulation carried out for a hypothetical five years period, characterized by an increase of levies of 10%, a decrease in precipitation of 15% (compared to the study period from 1999 to 2003) and a flow rate output from the lake of 0.5 m^3/sec (Basic flow index - minimum value identified as vital to the Marta river). These assumptions lead to a lowering of the average level of the lake compared to the years 1999-2003 about 20 cm and a considerable increase in the spare time of the lake water. The value of the latter passes for 120 years to 580 years, triggering a series of unforeseen environmental problems. Analysis similar to the example therefore allow to optimize the management of the system, taking into account the following main constraints: ensure to Marta river flows always superior to the BFI, maintain the level of the lake within a predefined range (between 304 and the 304.7m above sea level), to ensure the docking in the ports and prevent the lake from invading private land.

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The influence of anthropization over flow in a middle Italian basin. Different scenarios

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Keywords: Ground water storage, Reservoir, Hydrological Changes, Anthropization

Introduction

The modifications applied in our country by human activities over natural environments in the last decades, starting from the second world war, have a relevant impact on the hydrology answers of the system. Specifically the effects of anthropization are more intense around cities, where agricultural soils, which have an high infiltration index, have been modified into urban areas which are almost impermeable.

This phenomena generates different answer of the basins to the same input event in terms of peak discharge and volume and in term of water recharge of the deep aquifer. The percentage change of the soil use determines a different ground water capacity, that means higher peak in downstream, and less ground water storage. This generate a depletion in base-flow, which can cause environmental problems, and an impoverishment of the water system.

The study of this problem with a GIS program to change some parameters and to simulate different scenarios of anthropization can give indication for a future planning over water resource.

The goal of the study is to improve the knowledge of the hydraulic changes occurred over years of uncontrolled urbanization, the impact that this change have on natural environment and the strategy that should be used in the future for a better management of water asset in order to prevent extreme events, as stream-flow or long dry period.

Case study and methodology

In this study some results from different simulations over Mignone's river basin are presented.

The Mignone is a small basin, about 500 km^2, in the north of Lazio's region. It's characterized by an average altitude of 126.32 m.s.l.m. and there are five gauging stations, four of which are used in this study (Barbarano, Mignone, Bracciano, Allumiere), and one has been chosen as control station. The main stream is around 62 km of length.

Starting from a study over land use (Dati sul consumo di suolo in Italia, M. Munafò, ISPRA 2013), it's possible to build a curve of urban growth over Italian surface from 1900.

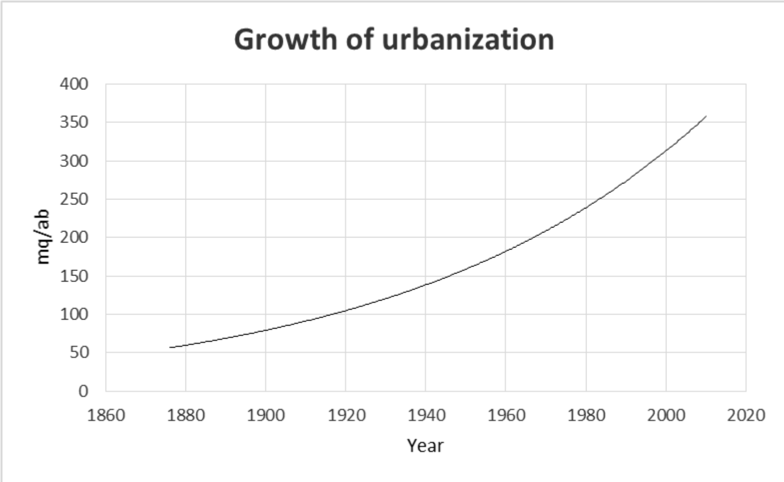

Fig. 1 Growth of urbanization over Italian land, from 1880. (Results obtained with a regression curve)

First it has been calculated the number of inhabitants over the basin in 2010, then the total amount of land transformed from agricultural to urban finding that over this basin there is a percentage of 9,5% of urban surface. Proceeding back and modifying manually the curve number shapefile, in particular by expanding the urbanized areas around the existing city, or reducing it as urban natural growth suggest, has been possible evaluate the hydraulic conditions for different steps: a growth of 1%, 3%, 6.1%, 9,5% and 13.1% of urbanization.

The program used in the simulations is an event based WFIUH simulator. In particular the results for three specific events are presented here:

- Event E1 del 07/11/2005
- Event E2 del 16/03/2006
- Event E3 del 25/03/2007

The program starts with an analysis of the geomorphological characteristics of the basin. In this case five geomorphological files were generated, dependent on the anthropization level, on which the hydrological net were built.

The next part of the program generates an analysis of the geomorphological raster (100m x 100m) files by the basin using an open-source application by Wolfgang Schwanghart called Topo-Toolbox. This application generates from a digital elevation model of the basin the drainage lines and hydrological path of it.

In the second part starting from the CN matrix is calculated the maximum potential retention S, and the initial abstraction I_a .

I_a=c*S

All these parameters are necessary to apply the curve number methodology, created in the '60 years from the Soil Conservation Service (United States agricultural department). This method allows us to generate a downstream simulation from rain gauge, and the rate of precipitation water losses in ground infiltration. The main equations of this method are:

$$Pn = \frac{(P - I_a)^2}{(P - I_a + S)} \qquad CN = 100 \cdot \left(\frac{S_0}{(S_0 + S)} \right)$$

Which are respectively used to evaluate net precipitation and curve number index for that particular ground.

At this point there is the separation between gross and net rainfall and in the last part the program evaluate the WFIUH. Here it is assigned to every cell of the DEM a value for velocity, based on Maidment equation. After that is calculated a width function for the river and after all is simulated the stream-flow for that event using a convolution.

$$Cxy(t) = \int_{-\infty}^{\infty} x(t - t)y(t)dt$$

Results

The results of the simulations are both relevant in terms of stream-flow and in terms of water recharge. The relevant increment in stream-flow of river generates a depletion in soil infiltration, this due to two different conditions. The first one is the soil impermeabilisation that naturally send the water away, the second one is the increment of surface runoff speed, even if it is very small.

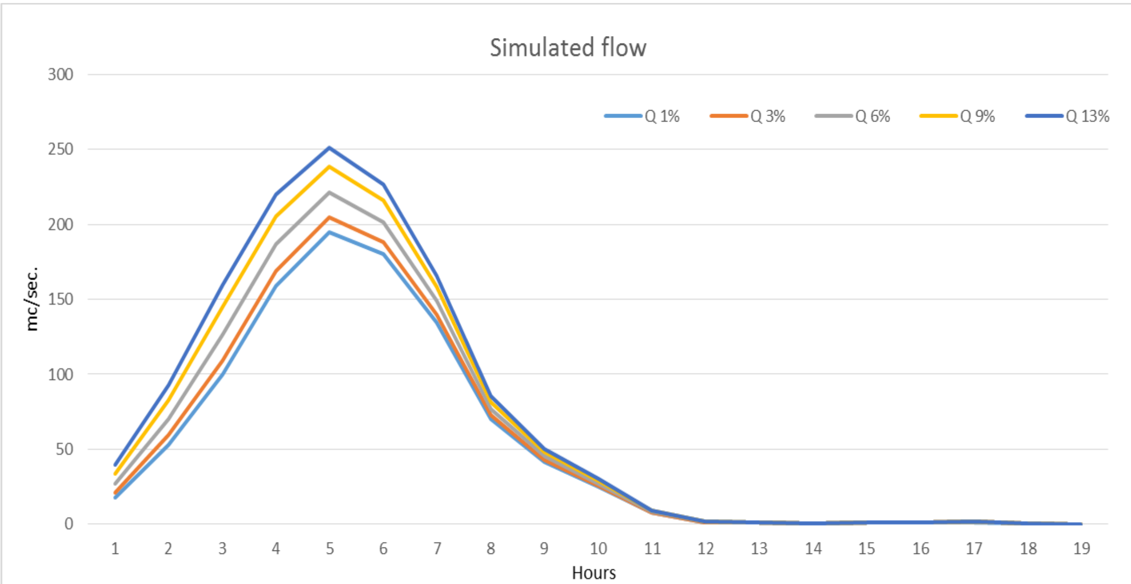

Fig. 2. Flow simulation over Mignone's basin. The difference between series is due to different Curve Number matrix. (Light blue = 1% Anthropization, Orange = 3%, Grey = 6%, Yellow =9%, Dark blue = 13%)

Figure two shows that the basin's answer changes sensitively by changing Curve Number matrix. In particular can be observed that the peak flow increases between Q1 and Q13 of around 56 mc/s, that means 30% over the total amount. This results are similar for all the simulations which means that are not dependent from the rain event or from the season.

The analysis of the results for ground water recharge are showed in the table below:

As we can see from table 1, the total amount of soil water changes after the shift of permeability of surface. In particular it decreases slowly for the first step of urbanization increment, then moves faster arriving at percentage bigger than 10%, and after that seems to came back around original increase.

However this simulation shows that on the long period, considering the whole simulation range, there has been a loss of water storage volume of about 40%.

Percentage Anthropization	Event 1	Event 2	Event 3
1%			
3%	7%	6%	7%
6%	11%	10%	13%
9%	12%	11%	14%
13%	10%	8%	11%

Tab. 1 Percentage of reduction of total ground water volume, per event, by the change of Curve Number

Conclusions

This work investigates a simple and fast way to estimate soil water recharge starting from a WFIUH model, based on the curve number method for calculating the losses due to ground permeability condition.

The results show that there is an increase over peak flow, which means a new perception of the urban growth in order to prevent stream-flow event, especially on that basin were the anthropization index is bigger and the city are located at the delta of the river.

The table 1 also shows that there has been, and is still proceeding, a depletion of natural ground water resource. It means a reduction of shallow aquifer water that generates a reduction of base-flow in the river, with all the consequences that this could generate.

A deeper analysis of the problem, supported by a new software that can calculate directly the water recharge process, is fundamental to prevent future problems in water management, connected with a section that can calculate base-flow, obtaining an unified process.

Another important challenge to proceed is the applicability of the method to other basins, to validate the results obtained, in order to extend a new concept of hydrological problems generated from a fast increasingly world.

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Water storage systems in innovative small scale hydro-power installations

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Keywords: weir, hydroelectric, micro-hydro, energy, reservoir

Introduction

Recently hydro power has been re-evaluated as being a precious "green" technology with development prospective for the future. Legislative framework worldwide is paying more attention to this renewable source, trying to support hydropower as a clean energy production technique. Despite the actual trend lots of work has yet to be done to achieve a good policy of management and utilization of hydropower. This source has interesting possibilities of growth, especially regarding low scale installations.

Water reservoirs are strictly related with hydropower generation. Each plant requires the realization of a certain water storage system, which capacity is dependent on the scale and on the plant typology. This paper investigates on the aspects that concern with the water storage systems in micro hydro power plants.

Hydropower is an aged technique; it is technically simple and reliable compared to others energy production technologies.

In terms of environmental impact and technological hazard it is worth to distinguish between large scale hydro plants and small scale hydro plants.

20th century has been characterized by terrible disasters like Vajont, Frejus etc., that concern with the realization of big dam (up to 150 million water cube meters storage) for large scale hydroelectric generation. Concerning with small scale hydro plants, technological hazard is very low: it is proportional to the water storage capacity. Regarding "run of river" plants technological hazard is practically zero.

Compared to other renewable energies, hydroelectric production can be forecasted and generally it is possible to produce energy, without intermittence, over most part of the year.

Hydro plants require very little maintenance compared to other energy production technology as wind generation, photovoltaic plants, thermoelectric systems etc.

Expected life time of a plant is generally more than 50 years, almost twice the one of wind farm and PV plants.

Hydroelectric generation generally requires consistent installation costs, but its realization represents also an opportunity to evaluate the river ecosystem, to make works concerning with water risk prevention, and to restore and preserve natural beauties of the river landscape.

This paper focuses on micro hydro plants, investigating about technical aspects and related water storage systems.

Materials and methods

There are two plant typologies distinguished by the water storage system:

- Run of river: those plants do not require a proper water impound, but just a weir to realize the intake structure to collect the water and divert it into canals or penstocks.
- Impoundment: in such plants it is necessary to design a proper water storage system able to accomplish the energy production requirements together with the river basin needs and the river environmental standards.

The choice between an impound design or a run of river one relies on many aspects:

- Technical feasibility and available site conditions (orography and flow regime)
- Energy requirements and uses (load characteristics)
- Technical and economic management (Realization cost and economic plan)

The ensemble of elements (weir or impound, trash rack, forebay ecc.) to collect water from the river, and divert it into a penstock or a canal, is given the name of intake structure. The intake must assure that the desired amount of water can be always supplied to the conversion machine. Run of river plants depend on the natural flow rate of the watercourse. Changes in the watercourse flow rate affect directly the output. Thus, this kind of plant is suitable for base service instead of peak service. Impoundment plants are characterized by the existence of a reservoir which enables flow regulation. As a consequence, the producible power can be independent from the flow regime. These characteristics make reservoir plants suitable to accomplish a power regulation service, i.e. to cover the peaks on the load curve.

First approach to the study was to explore a few study cases of existing pants, in order to understand technical solution and plant configurations.

In the second place a micro hydro feasibility study has been taken into account, identifying three different plant design solutions, each one with a particular water storage/collection system. Purpose of the investigation was to detect a target site characterized by certain significant conditions (small rivers characterized by dry season flow behavior).

The sample case taken into account occurred in a section of Arno river, located in the north side of the Casentino Valley (Stia (AR)-Italy). A dismissed water mill, originally used to produce grain floor, is located in the nearby of this section.

Results

As shown in Table 1, ten different micro hydro plants have been analyzed.

From this investigation it can be affirmed that micro hydro is likely to avoid the construction of big civil works, and in particular the realization of big impounds. The installation cost, indeed, would rise up with difficulties on paying back during plant life time, and peak service contribution would not be much relevant on the national grid scenario. For these reasons generally micro hydro plants belong to run of river typology.

The standard intake configuration, for large scale diversion, consists of a weir and a collection structure. A weir is basically, a barrage that maintains the water at a constant level. It does not store water, it just creates a small impound.

MYCRO HYDRO PLANT	P (kW)	Q_{design} (m^3/s)	H (m)	Plant typology
Kushadevi (Nepal)	4,7	0,01	>100	Run of river
Thima (Kenya)	2,2	0,028	18	Run of river
Mae Wei (Thailand)	8,5	0,035	50	Run of river
Mor Ti Hta (Thailand)	1,8	0,008	45	Run of river
Borrowash, Derbyshire (UK)	15 and 60	0,8 and 3	2.5 and 2.7	Run of river
Iles Mill, Gloucestershire (UK)	7	0.75	1,5 m	Run of river
Ostra Kvarn (Sweden)	33	1.2	2,2 m	Run of river
De Haandrik Weir (Netherlands)	100	7	2 m	Run of river
Roeven plant (Netherlands)	35	3	1.8 m	Run of river
Bucchio Mill, Casentino (Italy)	155	0.44	55	Run of river

Table 1. Comparison among ten different existing micro hydro plants

From this investigation it can be affirmed that micro hydro is likely to avoid the construction of big civil works, and in particular the realization of big impounds. The installation cost, indeed, would rise up with difficulties on paying back during plant life time, and peak service contribution would not be much relevant on the national grid scenario. For these reasons generally micro hydro plants belong to run of river typology.
The standard intake configuration, for large scale diversion, consists of a weir and a collection structure. A weir is basically, a barrage that maintains the water at a constant level. It does not store water, it just creates a small impound.
Fig. 1 shows a standard intake configuration for big withdrawal of water.

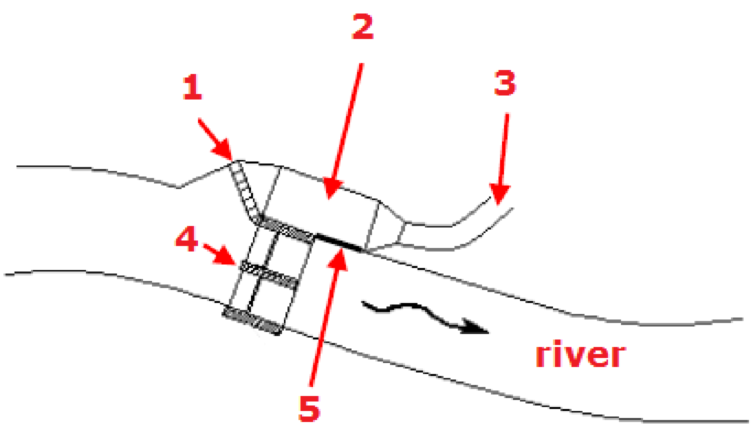

Fig. 1. Intake configuration for large diversion (Napolitano, 2012)

1. Trash rack
2. Forebay
3. Diversion canal
4. Weir
5. Divide

Sometimes the weir is designed to accomplish a double function: realize a small impound (intake function) and allow detritus sedimentation and removal (forebay function).

It is worth to mention that there are many micro hydro installations in which the turbine is located directly inside the impound (open flume Francis, very low head turbines etc.) or upon the weir (siphon turbine, Archimedean screw etc..). Fig. 2 shows an example of intake used in pico hydro applications and a description of the components follows.

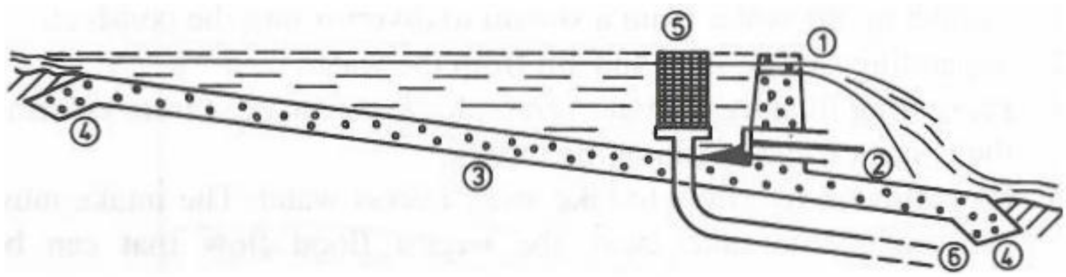

Fig. 2. Intake design with weir, penstock and flushing pipe (Williams, 2003)

1. Concrete retaining wall with overflow
2. Drainage pipe to flush away silt, with plunger and hung
3. Smooth concrete base – with max 10% of slope
4. Concrete skirt to prevent undercutting
5. Cylindrical wire mesh trash rack
6. Buried plastic penstock

The feasibility study demonstrated that is possible to realize a micro hydro plant in small rivers, such as the Arno river in Casentino Valley, at sustainable costs.
Three different solutions to exploit the source have been identified:

- Realization of a pico hydro solution in which a small turbine is installed in the existing embankment. This solution would generate 3 kW during all the year.
- Realization of a 390 kW plant with a single Francis turbine. This plant is supposed to work at rated power for around 3 months/year, during other 6 months/year it would work at partial power and for around 3 months/year the machine would not run.
- Realization of a 439 kW plant using the combination of two turbines. In this case the produced energy would be greater than in the previous case, and the period of non-production would be reduced at 1 month/year.

Discussion

Realization of micro hydro plants represents an opportunity not only for the production of renewable energy, but also to accomplish the water storage needs, to reduce flood risks and to improve watercourse management.
Design of new solution and development of water reservoir techniques for integrated systems is an interesting sector of research in the field of water management and hydropower. It is suitable for development, and it worth for further investigations.
Realization of small hydroelectric installations is also an innovative solution to retrieve ancient constructions like mills, dyeing plant, and other structures of the primordial industry located along rivers.

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What future for Lazio's lakes of Alban Hills? The situation of the Albano's Lake

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Keywords: water crisis, hydrological balance, lake lowering

Introduction

Lazio is one of the 20 administrative regions of Italy, situated in the central peninsular part of the country. This region is characterized by several crises and the most compromised are well known and include for example the the volcanic districts aquifers and the coastal aquifers. One of the most complex and crucial situation is represented by the Alban Hills, a volcanic complex situated in the southeast of Rome. In this area, the balance of volcanic and hydrological systems is changed by levies that are characterised by disturbing effects on the quantity and the quality of water resources. Nowadays, the current regime of exploitation of this resources is causing a progressive lowering of the Albano Lake's water level, causing severe environmental damages, additional to the recent phenomena of "water crisis". It is well known that in the last twenty years, in this area, the high indiscriminate use of water resources has implied the lowering of both the piezometric surface and the lakes level; the drying up of many wells and springs; an overall net decrease in the river flow caused by the volcanic area slopes. These events, together with the evidence of the depletion of aquifers, require urgent coordinated actions and specific studies for the quantification and management of water withdrawals. In this paper, the particular situation of Albano Lake, studied in the "Piano di Tutela Quantitativa (P.T.Q.) del Sistema Idrogeologico dei Colli Albani", is presented, trying to focus on the balance factors that have brought the hydrological crisis in order to individuate possible future actions to mitigate the water crisis problem.

Materials and methods

For a proper management of water resources is necessary to know the real requirements and the real withdrawals. For studying the water demand and withdrawals in the Albani hills, the "Piano di Tutela Quantitativa (P.T.Q.) del Sistema Idrogeologico dei Colli Albani" has considered two distinct approaches: the analysis of the water concessions database; and the indirect estimation, that depends on the soil use, the monthly trend of meteorological parameters (rainfall and temperature), the soils characteristics and the ISTAT (Italian National Statistical Institute) census data. The water supply for drinking water purposed in the Alban hills area has been defined by the Lazio Region through several studies for the PRGA (General Plan of the Aqueducts) update. As consequence, this latter states a detailed analysis of the problem. Aqueduct losses should be added to the values of net water required. The distribution and the amount of needs and water withdrawals for both industrial and production uses have been evaluated by two different methods: the first is the combination of specific values of water requirement per employee for each product category washed again in sections census (Census of Industry and production activities ISTAT 2001); the second consists in the data analysis of regional and provincial water concessions archives. Also the water requirement and then the withdrawals associated with irrigation have been evaluated by using two distinct and independent methodologies: the estimation based on physic-climatic and land use; the analysis of the practices of granting self-denunciation and well stored in the Lazio Region and the Province of Rome and Latina. Finally, the wells for domestic use are known only through the practice of the self-report.

Results and Discussion

The balance of volcanic and hydrological systems, in particular of the Albani hills, is changed by the levies, with disturbing effects on the quantity and the quality of water resources. The current regime of exploitation of this resource is causing a phenomenon of progressive water level lowering with severe environmental damage that is added to the phenomena of "water crisis" in recent years in this territory. These events, together with the aquifers depletion, require a crucial coordinated action for both the water withdrawals quantification and management. The area has several critical factors related to the lack of an adequate level of planning in the use of water resources. A first critical element is connected with the supply and the distribution of drinking water, with frequent "water crisis" in summer. These crisis are due to a combination of several factors such as: the growth of drinking water demand, the increase of population and the type of settlements, due to houses with irrigated gardens; the presence of local water systems not optimized respecting the acting loads, and often characterized by losses in excess respect the national average; the gradual weakening of the resources from cited Simbrivio aqueduct; the loss of local water supplies due to: water with physicochemical characteristics (traces of fluorine, arsenic, etc.) that limits its uses; drying up of wells due to the overexploitation of aquifers; the presence, in the last twenty years, of arid climatic conditions. The difficulties presented by the lack of supply of drinking water are additional to the requirements for protecting the water hydrological balance. This protection should be extended to important abstraction of water of good quality planned for use in drinking water mainly present in this area a gradual depletion of water resources exploited for both potable and industrial uses and irrigation has been observed. Sometimes with multiple competing uses concentrated in the same area. As noted, under current weather conditions and weather of land use, the hydrological system is strongly exploited and sometimes beyond the limit of the water balance. This can be confirmed by the values of minimum instream flow and abasement of the lakes. The imbalance of the water balance of the area of the Colli Albani should also be assessed taking into account the developments along the years of aquifer recharge and the progressive increase of water withdrawals.

Therefore The lines of action should be necessarily programmed by considering: that the rebalancing of the water balance of lakes requires action concentrated in the caldera, mainly on wells for drinking water; the rebalancing of the entire aquifer water budget requires action also extended to the distal areas aimed at the gradual decrease of water requirements and of the levy, with different priorities depending on the "impairment" degree of each sector of the aquifer observed.

The possible fields of action are: the reduction in the import supply of drinking water through water from areas outside of the hydrogeological system; the reduction of withdrawals for irrigation, industrial and domestic production, through the revision of the values given and / or that can be granted; water savings, encouraged by economic incentives. The imbalance of the water balance for the Albani hills area should be also evaluated taking onto account the years of the recharge of the aquifer and the progressive increase in water withdrawals.

Fig. 1. Recoiling of the Alban lake coastline: in the 2001 (light blue), and in the 2013 (dark blue)

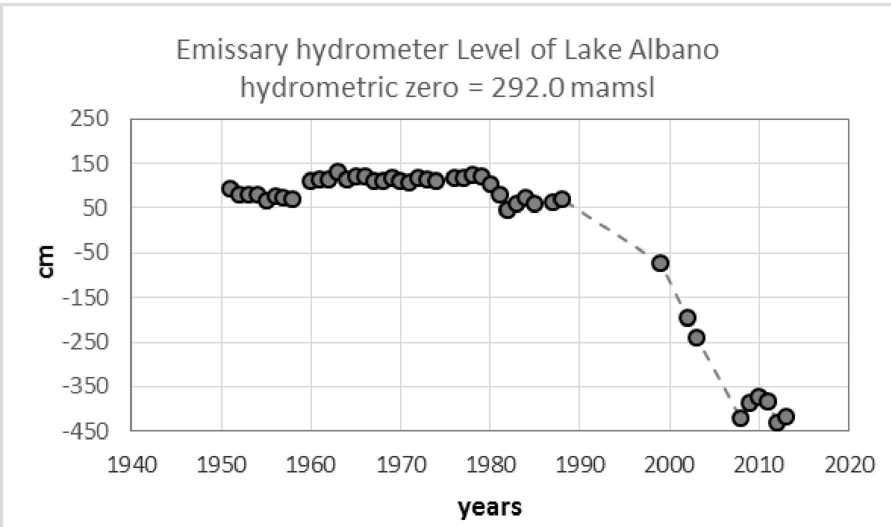

Fig.2. Emissary hydrometer Level of Lake Albano

	1960-80	1981-85	1986-90	1991-96
Rainfall [mm/year]	1090	1010	934	1005
Net Rainfall [mm/year]	479	425	379	378
Surface Flow [mm/year]	136	124	114	123
Infiltration [mm/year]	343	301	265	255
Rainfall variation	0.0%	-8.0%	-14.0%	-7.8%
Infiltration variation	0.0%	-13.0%	-23.0%	-26.0%

Tab. 1. Rainfall and Infiltration variation between 1960 and 1996

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Graphical flow duration curves regionalization method based on instantaneous measures

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Keywords: Hydroelectric, flow duration curves, regionalization, reservoir

Introduction

Flow duration curves are usually related to water resources engineering and they are used to solve issues in the water quality management, hydropower, water use planning, flood management and river and reservoirs regime (Vogel and Fennessey, 1995). Indeed, flow duration curves represent one of the most significant and most widely used tools to assess the amount of water resource in a river cross-section. These curves are easily constructed in river cross-sections provided with hydrological gauging stations. For ungauged sections, many authors have studied methods that derive flow duration curves even in the absence of data (a review and the reliability of different methods is studied in Castellarin et al., 2004). These techniques are generally based on the identification of homogeneous regions (Nathan & McMahon, 1990). Once that the homogeneous region is identified, the information can be transferred using appropriate procedures from the region itself to one specific site.

The annual flow duration curves (AFDC) are constructed in this work (Vogel & Fennessey, 1994; Castellarin et al. 2007).

The procedure used in this work to regionalize the AFDC is the graphical approach (Smakthin et al. 1997).

It consists of the following steps:

1. create a dimensionless flow duration curve for each different measurement station of the region by dividing the flow data for the station average discharge value measured over the long term;
2. identify the regional dimensionless curve *X(D)* as the mean of curves created in the first step;
3. the ungauged river section AFDC is then reconstructed by multiplying the regional dimensionless curve *X(D)* for the mean value of flow rate in the long term, *Q**, of the given site. To estimate the average annual flow *Q** at the ungauged site, either direct models are used (Niadas, 2005) or models that take advantage of geomorphological and climatic conditions data.

In this work, a method based on a direct estimate of *Q** is applied. Specifically, the hypothesis of obtaining the *Q** value by spot measurements is done. The aim of the paper is to determine the minimum number and the best period of measurements necessary to obtain the better flow duration curve for the considered station.

Case study and methodology

The analysis carried out in this work concerns the basin of the Liri-Garigliano; it covers an area of approximately 4900 km^2 in Central Italy.

In the case study the graphical approach mentioned above was chosen: therefore we proceeded to the construction of the *X(D)* curves for ten gauged stations of the Liri-Garigliano basin (1993-2008 time series).

The *Q** value was calculated for each station using different spot measurements sampled with different time lags:

Every 1, 3, 5, 10, 15, 30, 120, 180 days in the entire dataset;

For each year one value is extracted every 30 or 15 days in a time frame of six months.

This procedure is repeated shifting the extraction period of one month, in order to understand if there exists an optimal period to sample data series. Then, the mean value of all years is found.

In order to assess the performance of the proposed technique, the jack knife procedure was adopted:

- 10 stations belonging to the region were considered;
- one of the 10 stations is removed;
- the regional flow duration curve *X(D)* is found by averaging the 9 dimensionless FDC;
- the removed station's AFDC is obtained from the product between *X(D)* and *Q** (obtained for the removed station as explained above);
- the procedure is repeated 10 times, excluding one station each time;
- we finally compare the AFDC with the corresponding empirical one.

With the aim to identify the best theoretical curves, we use two statistical indexes, the MSE (Mean Squared Error) and the BIAS :

$$MSE = \frac{1}{N}\sum_{i}\frac{(Q_{ti} - Q_{si})^2}{Q_{si}}$$

$$BIAS = \frac{1}{N}\sum_{i}\frac{(Q_{ti} - Q_{si})}{Q_{si}}$$

where N=the number of days in the year, Q_{ti} is the simulated valued and Q_{si} is the empirical value.

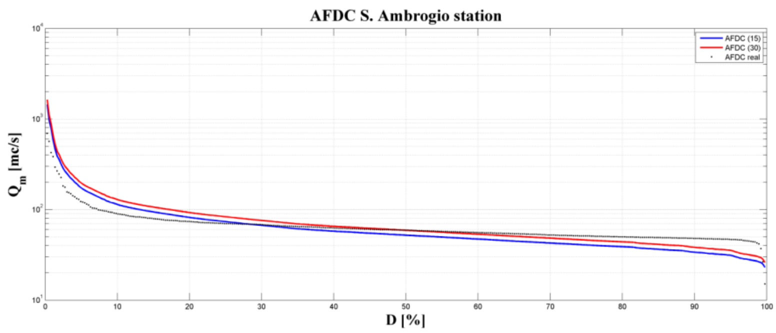

Fig. 1. *AFDC* empirical (black) and simulated curves (for discharge values sampled every 15 and 30 days in blue and red, respectively) for S.Ambrogio Station

Discussion

In Figure 1 the AFDC for the S.Ambrogio station is shown. The real curve is plotted together with the AFDC built with 15 and 30 days sampling times.

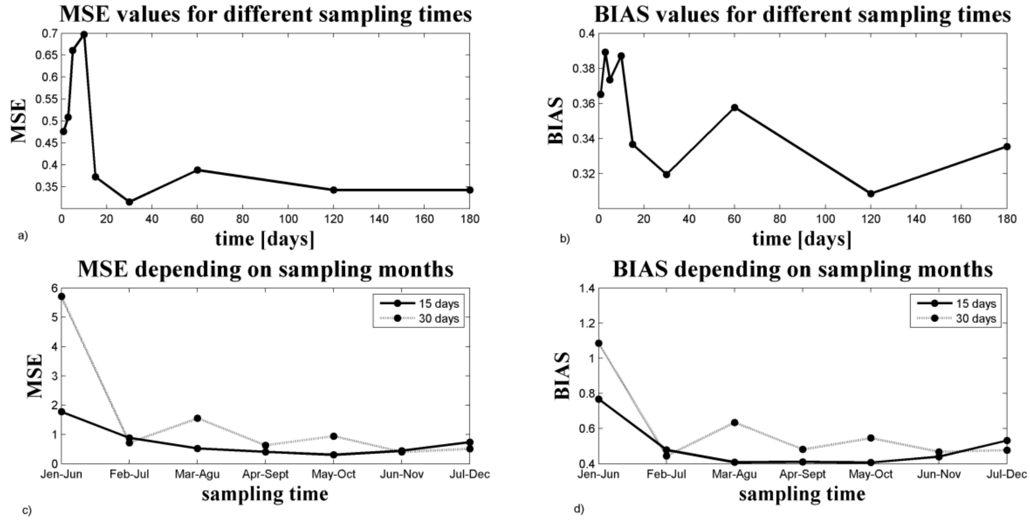

Fig. 2. MSE and BIAS values against the different sample times. In Figs. 2a and 2b, MSE and BIAS are plotted against 1, 3, 5, 10, 15, 30, 120, 180 days. In Figs. 2c and 2d the dotted and continuous lines represent the MSE and BIAS values calculated with sample times of 30 days and 15 days, respectively

Figures 2 shows the MSE and the BIAS against different sample times. Specifically, the Figure 2a shows that the MSE value has a maximum for 10 days sample time, while it strongly decreases after 15 days sample time. Figure 2b shows that the BIAS curve has the same behavior of the MSE, but it is not particularly affected by the sample lag as its variation is not high.

Figure 2c represents MSE values against the sample time period. The dotted and continuous lines represent the MSE calculated with a sample time of 30 days and 15 days, respectively, in each six months group.

Figure 2d represents BIAS values against the sample period. The dotted and continuous lines represent the MSE calculated with a sample time of 30 days and 15 days, respectively, in each six months group.

Figures 2c and 2d show that the error is high for the 30 days sample lag for the January-June sampling period, while it is quite constant in the other periods. The 15 days sample lag shows a constant tendency with lower error values. This behavior is probably due by the fact that the January-June sample time is not completely representative of the whole hydrologic year.

Conclusion

This work investigates a direct method to estimate AFDC using spot measures. Indeed it examines if there is an optimal lag time and year period to sample discharge values.

The methodology shows interesting future perspectives as the error between the observed and simulated values is characterized by low values. Besides, the method gives indications about the optimal lag frequency and measurement year period. It is showed that a descriptive period of the year, comprehending minimum and maximum discharge values, should be considered.

To better validate this method, it will be tested in different regions. Besides, an optimization procedure based on the minimization of the MSE should be studied. Further developments are ongoing to enhance the approach.

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Cyanobacteria blooms in Lake Chaohu observed from time-series MODIS images

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Keywords: Eutrophication; Cyanobacteria bloom; Floating algae index (FAI); Algae pixel growing algorithm (APA); Lake Chaohu; MODIS

Introduction

Because of 3 decades rapid economic development, eutrophication is one of the most pervasive water quality problems in China, just like in many parts of the world. And algae and macrophyte blooms are often observed, especially in Lake Taihu, Lake Chaohu and Lake Dianchi (Duan et al., 2009; Jia et al., 2011; Dai et al., 2012). Benefiting from remote sensing technology, the existing publications concerned much more on algal blooms in Lake Taihu, and longterm temporal and spatial distributions of algal blooms and their environment driver force analysis were popular to be focused on (Hu et al., 2010; Huang et al., 2014). However, to date there has been no published work in establishing a long-term, reliable record of phytoplankton blooms in the other lakes of China where algal blooms also take place based on satellite data.
The objectives of this paper are: 1) to use a algae growing algorithm based on floating algae index (ab. FAI-APA) and MODIS satellite images to derive the algal bloom spatial and temporal information of Lake Chaohu; 2) to explore the possible underlying mechanisms for algal blooms in Lake Chaohu. This study is expected to contribute to water quality control and bloom prevention of inland freshwater lakes and to benefit some regional-scale studies.

Materials and methods

2.1 MODIS data acquisition and processing

About 2100 MODIS images that cover the period of 2000-2013 were downloaded from the NASA EOS Data Gateway (EDG). MODIS data (dimensionless) were georeferenced to UTM projection with an error of less than 0.5 pixel. MODIS data were corrected by removing the molecular (Rayleigh) scattering effects, and then converted to Rayleigh-corrected reflectance (Rrc) following Hu et al. (Hu et al., 2004). The Floating Algal Index (FAI) algorithm (Hu, 2009) was used as:

$$\mathrm{FAI}_{MODIS} = R_{rc}(859) - R_{rc}^{'}(859) \tag{1}$$

with $R_{rc}^{'}(859) = R_{rc}(645) + [R_{rc}(1240) - R_{rc}(645)] \cdot (859 - 645)/(1240 - 645)$

2.2 Cyanobactria coverage product

In this article, cyanobacteria coverage of every pixel was achieved according to Zhang's approach (Zhang et al., 2014). Supposing that the FAI of the central pixel in a 3×3 pixel window could be a linear composition of the maximum and minimum FAI in window, then FAI of the central pixel could be expressed as,

$$\mathrm{FAI}_{MODIS}{}^{pixel} = \gamma \cdot FAI_{MODIS}(Max^{pixel}) + (1-\gamma) \cdot FAI_{MODIS}(Min^{pixel}) \quad (2)$$

where γ is the decomposition parameter of the 3×3 pixel window.

We define the algae coverage as the proportion of area covered by floating algae in a mixed pixel. Assuming that the relationship of FAI and coverage of a mixed pixel can be expressed as,

$$FAI = \alpha \cdot FAI_{algae} + (1-\alpha) \cdot FAI_{non-algae}$$

$$= \left(FAI_{algae} - FAI_{non-algae}\right) \cdot \alpha + FAI_{non-algae} \quad (3)$$

where α is the coverage of the thinnest floating algae ($FAI=FAI_{algae}$) in a mixed pixel, FAI_{algae} and $FAI_{non-algae}$ are the thresholds of floating algae and non-algae respectively. Consequently, FAI has linear relationship with floating algae coverage for mixed pixels. The FAI of a max pixel and a min pixel in a 3×3 pixels window could be expressed as,

$$FAI_{MODIS} = \mathrm{m} \cdot \alpha + \mathrm{k} \quad (4)$$

where m and k are the slope and intercept respectively. Combining equations (3) & (4), coverage of mixed pixel is described as,

$$\alpha_{MODIS}{}^{pixel} = \gamma \cdot \alpha_{Max} + (1-\gamma) \cdot \alpha_{Min} \quad (5)$$

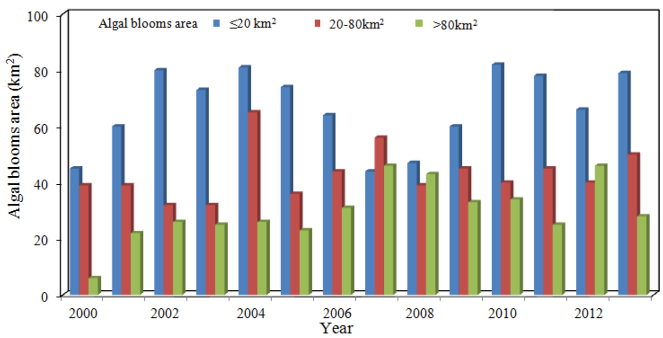

Fig. 1. The counts for different level of algal blooms areas in Lake Chaohu from 2000 to 2013

Results

The spatial and temporal distribtuions of algal bloom show that for the three lake segments as well as the entire lake, there is an apparent difference between the 2000-2006 and 2008-2013 periods, with 2007 being the transition year. Assuming that 80 km^2 and 20 km^2 were regarded as the classification criteria of the algal bloom size (heavy, moderate and slight blooms), in 2000 heavy blooms occurred in low frequency(shown in figure 1). But they became much more often occurred in 2007, 2008 and 2012, especially during summer months. Interestingly, slight blooms time-series counts exhibited the trend to the contrary of heavy blooms.

On the basis of 25% bloom area coverage as a measure of significance, the initial date of blooms in each lake segment is summarized in Table 1. Through the past 14 years, two distinct changing tendencies were detected; from 2000 to 2004, the algal blooms outbreak showed a slightly delaying tendency, with a delay of 10 days per year. However, since 2005, its outburst became much earlier than before and had been brought forward to the beginning of March, excluding 2010 and 2013. The initial blooming date spatial distributions shows that all the time the north area of West Lake was the first bloom location appearing in this lake.

Year	East Lake		Middle Lake		West Lake		Lake Chaohu	
	Starting Days	Duration	Starting Days	Duration	Starting Days	Duration	Starting Days	Duration
2000	106	155	106	173	106	176	106	165
2001	131	125	95	161	61	295	115	279
2002	151	118	150	245	76	193	102	145
2003	155	111	140	126	105	291	145	130
2004	115	236	115	236	69	282	119	232
2005	69	260	117	147	67	267	69	234
2006	65	332	65	332	65	332	65	301
2007	83	314	66	330	66	331	45	352
2008	85	216	85	234	61	295	98	212
2009	68	242	69	235	68	307	68	242
2010	130	257	53	334	53	309	53	230
2011	70	276	99	292	70	288	70	261
2012	70	264	70	274	57	277	70	274
2013	101	258	101	258	66	293	101	258

Table 1. Frequency of significant cynaobacteria blooms in each lake segment of Lake Chaohu

The bloom duration in each year is defined as the difference between the first and last day that a bloom is present in MODIS imagery. For most of the lake, 2007 showed longer bloom durations than the other years. The trend actually began in 2006, with 2007 being the worst bloom year. Indeed, more than 3 quarters of the entire lake had blooms lasting for >8 months during 2007. Similar long-lasting blooms were also found in West Lake during 2000 and 2013.

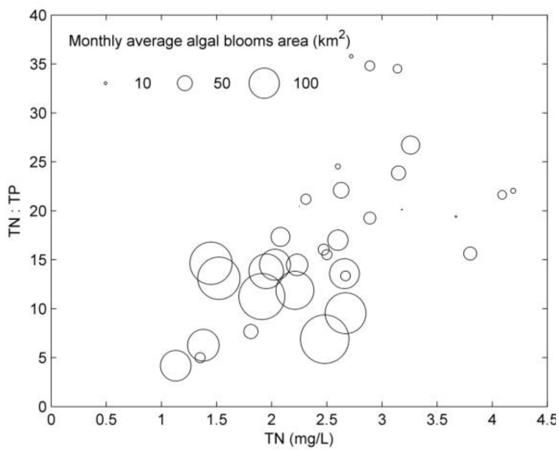

Fig. 2. Bubble plot of nutrient (TN and ratio of TN and TP) and monthly average algal blooms in Lake Chaohu during 3 years (including 2008, 2012 and 2013). Bubble size is monthly average algal blooms area

Discussion

We collected 3 years (including 2008 (Jia et al., 2011), 2012 and 2013) monthly N and P concentrations of Lake Chaohu to achieve the relationship between cyanobacteria blooms area and nutrients. Bivariate correlation analysis revealed that algal blooms area and the ratio of N and P, or N concentrations appeared in obvious negative correlation ($P \leq 0.001$). And P concentrations showed weakly significant correlation with blooms area. Figure 2 demonstrated that both of low TN:TP ratios ranging from 5:1 to 15:1 and low TN concentrations varying from 1.0 to 3.0 mg/L favored heavy algal blooms.

At high temperatures, cyanobacteria exhibite optimal growth rates and compete most effectively with diatoms, chlorophytes and cryptophytes etc (Hans & Paerl, 2009), which was also comfirmed by seasonal variation of cyanobacteria blooms area in the Lake Chaohu. We found that algal blooms area were positive correlated with temperature (R^2=0.510,$P \le 0.001$). With the increase in temperature, precipitation from East Asia monsoon could be unfavourable for cyanobacteria growth due to wind-induced vertical mixing and lack of adequate illumination, but the rising trendency of cyanobacteria couldn't be much affected.

The average wind speed during 2000 to 2013 in Lake Chaohu was no morethan 3 m/s, and wind speed in summer was much lower than that in winter, which favored cyanobacteria floating to the surface very much. It seemed that south wind was propitious to cyanobacteria blooms rather than prevailing North northwest wind and east wind. In fact, south wind could prevent cyanobacteria blooms expanding to middle and east lakes, resulting in cyanobacteria accummulation along the north coast of west lake.

Therefore, formation mechanism of cyanobacteria blooms was very complicated, which was the intergrated results of all environmental forces, such as the supply of nutrients, temperature, wind, sunlight and lake topography etc. Otherwise, profound human influence was much more than that above-mentioned. Numerous dams/sluice gates and water transfer projects have been built to serve the purpose of flood control, navigation, irrigation and drinking water supply. Although the factors controlling cyanobacteria blooms are quite complicated, eutrophication first is the consequence of elevated nutrient levels.

Acknowledgements

We would like to acknowledge the financial supports provided by the National Natural Science Foundation of China (No. 41101316).

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Spatial and seasonal variability of turbidity in Lake Kahokugata, a shallow eutrophic lagoon in Japan

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Keywords: land reclamation, turbidity, eutrophication, suspended matter

Introduction

A number of land reclamation projects have been conducted at coastal lagoons since 1950s by Japanese Ministry of Agriculture. Lake Kahokugata was one of brackish lakes located in the central island of Japan. Land reclamation had been conducted at the lake during from 1963 to 1971, and a tide gate was constructed in 1980. The surface area of the lake has decreased from 23 km^2 to 4.13 km^2. Since then, the brackish lake has turned into a fresh water lake.
The trophic status of the lake deteriorated severely after the tide gate construction with an increase in nutrient loads from the catchment area. There are about 125,000 residents in the catchment area of the lake. Although efforts have been made to reduce nutrient loading from point sources, current trophic state of the lake is hypereutrophic. It seems that the lake condition has switched from a clear water state to a turbid water state (Scheffer et al. 1993, Scheffer & van Nes 2007).
Physical and chemical properties of the lake water were surveyed to analyze the spatial and seasonal variability of turbidity in the lake in 2013.

Methods

Lake Kahokugata has a maximum depth of 4.8 m and a mean depth of 2.0 m (Fig.1). We prepared 16 survey sites to check the entire lake. The lake water survey was carried out monthly from March 2013 to March 2014 at St.3 near the outlet canal and St.9 near the inlet canal.
The spatial variation of the surface water properties were surveyed throughout the lake (St.1-16) on August and October, 2013.
Water temperature, pH, electric conductivity (EC) and dissolved oxygen (DO) were measured using electrode meters. Underwater light was measured to calculate the light-extinction coefficients by a quantum sensor (Li-Cor, 193SA). Secchi disk transparency was measured.

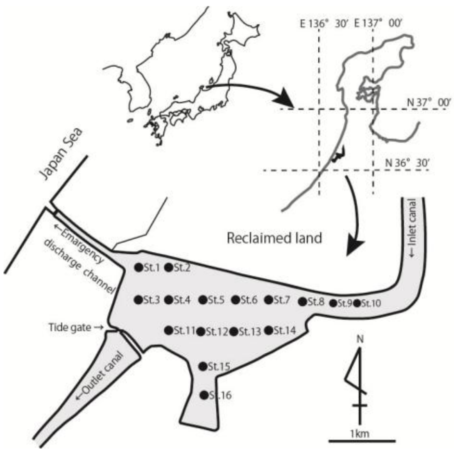

Fig. 1. Map of study sites

Surface water (0.1m depth) was collected to measure concentration of chlorophyll-a (Chl-a), total nitrogen (TN), total phosphorous (TP) and total organic carbon (TOC). To measure organic and inorganic suspended solids content, the lake water samples were filtered through a glass filter (Whatman, GF/B). Dissolved matter contents that pass through the glass filter were also measured.

Results

The lake water was severely turbid throughout the year (Fig. 2). The maximum values of Secchi disk depth did not exceed 1.0 m at St.3 and St.9.

The values of secchi depth at St.9 were slightly larger as compared to those at St.3. The values of secchi depth decreased at these sites toward winter. The seasonal secchi depth changes corresponded with the light-extinction coefficient of the surface water.

The maximum concentration of Chl-a was observed 72.7 micro g l^{-1} at St.3 in May. The values of Chl-a also decreased at these sites toward winter. It was clear that the increase of phytoplankton biomass had no relation to the present status of water turbidity.

The values of total suspended solids and inorganic suspended solids increased toward winter. The values of these substances at St.3 tended to be larger as compared to those at St.9. A significant correlation was observed between the Secchi disk depth and the inorganic suspended solids content.

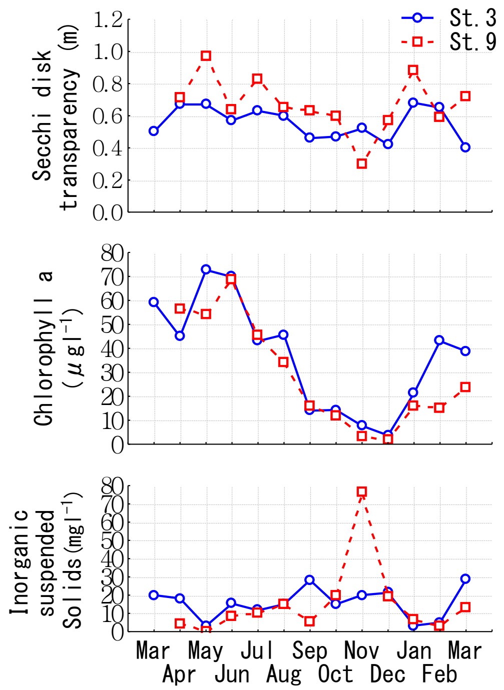

Fig. 2. Changes in Secchi disk transparency, Chl-a and Inorganic suspended solid at St.3 and St.9

Discussion

In shallow lakes, resuspension of sediment can be generated by wind induced waves (Arfi et al 1993, Hamilton & Mitchell 1996). Although this process is a major factor controlling the water turbidity, the depth of the lake and the local wind conditions were the same as before.

Recently, increase of water turbidity was observed in Lake Kasumigaura where tide gate has been constructed. It was reported that a critical shear stress for the bottom sediments became lower than before (Seki et al. 2006). In general, sedimentation rates increase with salinity. Therefor, the decreasing sedimentation rate is one of the major factors influencing turbidity in the present lake.

Acknowledgements

We wish to thank Ishikawa Rowing Association for its support of our field survey. This research was funded by Kahokugata Restoration Association (Kahokugata Kankyou Taisaku Kiseidoumeikai).

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ECOLOGY AND BIOLOGY OF LAKES & INLAND WATERS

Impacts of Climate Change on Lakes in Japan - Prediction of Impacts on Lake Biwa

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Keywords:
Climate change, Climate model, Lake circulation, Impact on ecosystem

Introduction

In order to clarify the impact of climate change on the environment of lakes, this research predicts the impacts on ecosystems and the water quality of Lake Biwa under the given weather conditions for the future utilizing a climate model and a water quality analytical model.

Climate model

In this research, MRI-AGCM3.2S, which is created by Japan Meteorological Research Institute, is utilized because this is a leading model in the currently available climate models. The time periods of prediction are 10 years for the current climate (1994-2003) and 10 years for the near future (2030-2039). The near future climate is predicted according to the variation of the current climate factors such as temperature, solar radiation, precipitation, etc. The spatial resolution is about 20km mesh, and the emission scenario is SRES-A1B. Although wind is one of the factors that should be taken into account to analyze the heat balance and local wind current of lakes, this research assumes that wind speed and directions in the near future climate will be the same as those in the current climate because of the constraint of the analytical model.

Table 1 summarizes output values of the climate model for Lake Biwa watershed. Compared with the current climate, the annual average temperature increases 1.1 °C, and precipitation increases 4% in the near future climate.

Climate factors	Current situation (AMEDAS value) 1979～2003	Near future climate (amended) 2015～2039	Difference/ratio
Temperature[°C] Annual average temperature of 25 years	14.3	15.4	+1.1
Precipitation [mm] Annual average precipitation of 25 years	1,780	1,857	×1.04
Solar radiation [MJ/m2] Average of annual cumulative solar radiation in 25 years	4,563	4,623	×1.01

※DFDM Implementation of amended bias by CDFDM method

Table 1. MRI-AGCM3.2S Predicted climate change in the future of Lake Biwa

Formation of model, and items for prediction and evaluation

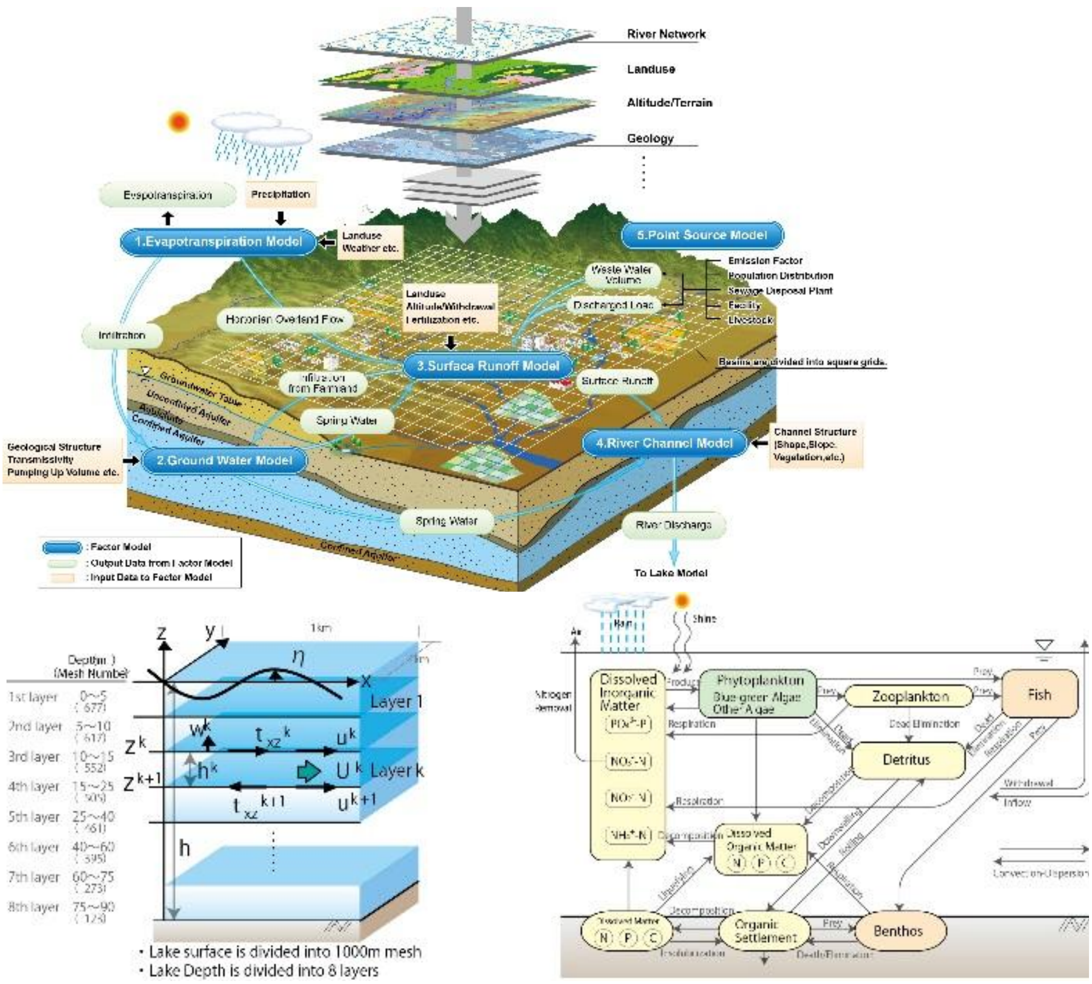

Fig. 1. Water quality analytical model

The analytical model for water quality of Lake Biwa is based on three sub models, which are shown in Figure 1; the terrestrial model, the inner lake flow model, and the lake ecosystem model. According to the given conditions such as temperature, solar radiation, precipitation, the terrestrial model analyzes flow rate, temperature and water quality of watershed (river); the inner lake flow model analyzes flow, temperature and water quality inside the lake; the inner lake water quality model analyzes organic matters (dissolved and suspended), nitrogen and phosphorus (inorganic and organic), dissolved oxygen and chlorophyll a. The results are evaluated statistically (average and percentile) and presented in a graph showing monthly variation for 10 years.

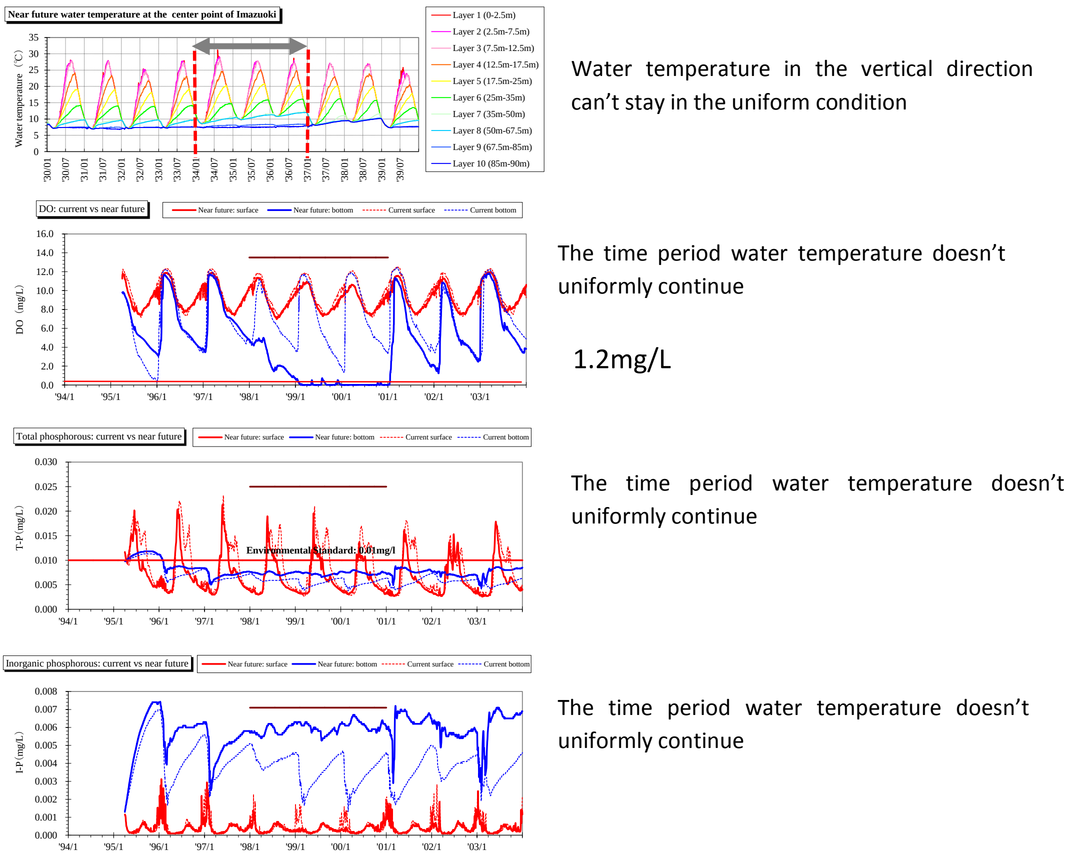

Fig. 2. Monthly variation of water temperature in the vertical direction (Near future climate, center point of Imazu offshore) and comparison of water quality in current climate and near future climate in surface and bottom at the center point of Imazu offshore

Variation of inner lake temperature

Comparing the current climate and near future climate, the result shows that annual average temperature increases from 15.3 °C to 16.6 °C at the center point of Imazu offshore.

Variation of entire lake circulation

Figure 2 shows the monthly variation of water temperature in each layer. The result shows that the water temperature in the winter months is not uniform in all layers from 2034 to 2036, which means that there are two layers in accordance with the water temperature.

Change of lake water quality

Figure 2 also shows the result of lake water quality analysis at the center point of Imazu offshore. In the period that the water temperature in all layers does not become uniform during the winter months, that is each year during 2034 to 2036, lower DO gradually decreases through the whole year. The result also shows that the concentration of phosphorus in the bottom layer would increase according to the decreasing DO in the bottom layer.

Impact on ecosystem

According to the predicted result of water quality, DO at the bottom of the lake will continue to decrease. Therefore, the impacts should be researched focusing on the bottom of the lake, which is a habitat for grown Gymnogobius isaza. Median lethal concentration of dissolved oxygen for Gymnogobius isaza (LC50) is around 1.2mg/L. The result indicates that the concentration of dissolved oxygen will decrease below LC50 for a few days at 70 m in depth (about 24% of the Lake Biwa area) at the center pont of Imazu offshore. In addition, the result suggests that low DO values under LC50 would be observed through the whole year at 90m in depth.

Conclusion

Based on the results of this study, more detailed impacts on Lake Biwa should be researched. Also, the impacts on Lake Hachiro, Lake Ikeda and other lakes in Japan should be researched and summarized as well.

Analysis of the climate change effects on the Bracciano lake (Italy) using numerical model application

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Keywords: Numerical groundwater model, Lake Bracciano, hydro-meteorological time series

Introduction

Bracciano volcanic caldera lake (Italy) is part of the Sabatini Hydrogeological Unit. Studies indicate that the lake is in direct contact with the main aquifer. The area is exposed to continuous stresses from several public and private pumping wells tapping the groundwater aquifer. Over the last thirty years the withdrawals from the aquifer have increased. Another stress on the system is climate change leading to changes in precipitation and temperature conditions, which in turn affect aquifer recharge and the lake water budget. The effects of global warming are increasingly evident (IPCC 2014), and are expected to lead to an increase in the use of groundwater. A numerical groundwater flow model on the Bracciano lake and its hydrogeological basin was constructed using the finite-difference code MODFLOW2000. The model was implemented for steady state, at first and it was calibrated. After that, it was implemented for transient (monthly time steps over six years) conditions. The Bracciano model was applied to simulate possible climate change and water-use scenarios to better understand the behaviour of an example volcanic lake under multiple stresses. The Bracciano model simulation results helps understanding the climate change effects on groundwater and lake water balance. It could also be a useful tool for analysing climate change adaptation strategies for water supply and groundwater and lake dependent ecosystems.

Materials and methods

Bracciano volcanic caldera lake is in direct contact with the main aquifer (Mazza et al. in press). The lake recharging area is exposed to stresses from several public and private pumping wells tapping the groundwater aquifer. It has been an increasing in the wells withdrawals over the last thirty years. A spatial interpolation of weather station information including rain and temperature (data over last 50 years), were considered as input values for the modelling of groundwater and lake water balance. Considering an area of around 360 km^2, a two layer numerical groundwater flow model was built to represent the aquifer, using the finite-difference code MODFLOW2000 in Groundwater Vistas 6.1 (Rumbaugh and Rumbaugh 2004). Around 2000 different uses pumping wells have been included. From regional water management plan data on water supplied for potable uses have been taken.

Firstly, a steady state version of the model was calibrated using PEST (Doherty 2008). From the steady state model results it was implemented a six-year transient simulation that extended from 2000 to 2005 (MODEL T5). In a second step a "MODEL A" was simulated considering a dry scenario characterized by increased temperature and so lake evaporation by a 1.1 factor and reduced aquifer recharge by a 0.9 factor. Imposed conditions for the dry scenario have been considered as reasonable in relation to the analysis of the 1975-2010 trend weather data. Model A simulation leads to a shift in the importance of the three drivers that control lake level (Net precipitation, Net groundwater flow, and Surface water inflow).

Results

Performing results came out from steady state calibrated model. The calibration of the steady state model took account of more than 100 head targets and of 8 flux targets related to main lake inflow and outflow streams. An Absolute Mean Error of 10.2 M for head targets was considered as a reasonable discrepancy for a basin scale model.

Simulation results shows the strong role of Net precipitation influencing lake level trend, rather than Net Groundwater flow or Surface water inflow.

Results coming out from MODEL A simulation, led to a gradual decline of the lake level equal to 0.3 M after six years compared to the T5 simulation (Fig. 1).

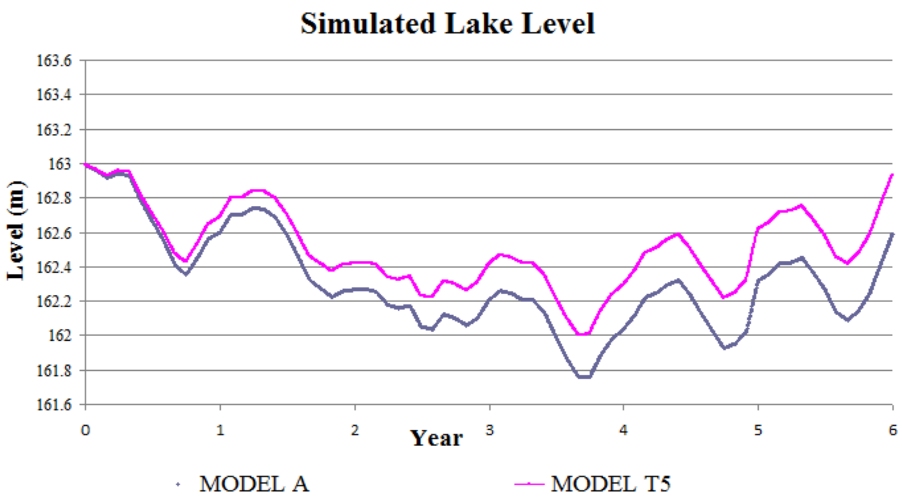

Fig. 1. Simulated lake level, MODEL T5 and MODEL A

Fig. 2 shows that Net Groundwater flow to lake increases (MODEL A in comparison to MODEL T5) despite lower recharge, because lake level have dropped primarily as a function of lower Net Precipitation and then resulting in stronger hydraulic gradients toward the lake. The increased Net Groundwater flow contribution partially compensates for decreased Net Precipitation.

Discussion

The comprehension of aquifer-lake interaction in volcanic lakes could be enriched from the Bracciano case study. The Bracciano model simulation results helps understanding the climate change effects on groundwater and lake water balance. It could also be a useful tool for analysing climate change adaptation strategies for water supply and groundwater and lake dependent ecosystems.

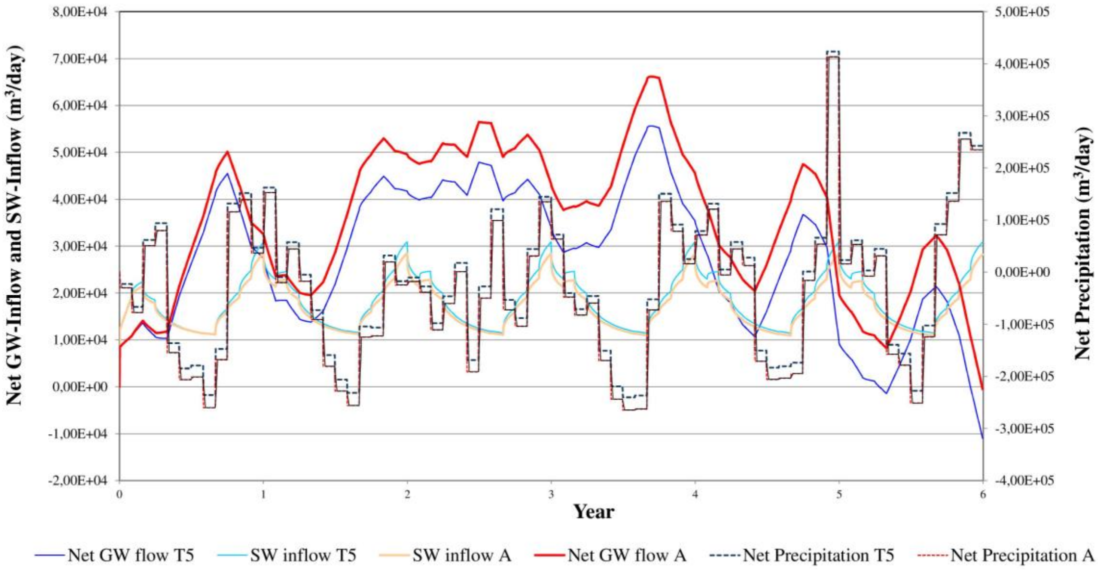

Fig. 2. Three drivers controlling lake level (Net Precipitation: Net Groundwater flow and Surface water inflow) for both, MODEL T5 and MODEL A

Acknowledgements

The authors wish to acknowledge Daniel T Feinstein (USGS Wisconsin Water Science, Center University of Wisconsin-Milwaukee).

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Observed Lake Baikal Plankton trends - result of natural processes or climate changes?

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Keywords: Plankton trends, climate changes, pollution, Lake Baikal

Introduction

There were several researches, devoted to the influence of global warming on some parameters of the lake Baikal ecosystem. The real complex studies of the reaction of the lake ecosystem as whole to the changes of climate forming factors are just started. The recent researches of our team have revealed the increase of water temperature at different depths. This trend of temperature is followed by remarkable increase of the summer plankton biomass (Hampton et al., 2008; Moore et al., 2009).

The under-ice complex of alga species of the Lake Baikal is characterized by the explosive under-ice development of endemic diatom algae, with periodical extremely high yields. In the recent paper we analyze our data, allowing the estimation of consequences of the climate change for the lake Baikal under-ice phytoplankton complex, namely, the most abundant species like *Aulacoseira baicalensis* (K. Meyer) Simonsen, *Stephanodiscus meyerii* Genkal et Popovsk., *Cyclotella baicalensis* (K.Meyer) Skv, as well as for summer phytoplankton complex (*Chrysochromulina parva* Lackey, *Rhodomonas pusilla* (Bachm.) Javor, *Monoraphidium pseudomirabile* (Korschik.) Hindak et Zagorenko). Previous analysis of zooplankton dynamics demonstrates some trends for increase of main component of zooplankton, *Epischura baicalensis*, some increase of co-dominant species *Cyclops kolensis*, decrease of number of endemic Rotifera, growth of number of non-endemic Rotifera. Here we'll discuss the recent results of dynamics of total zooplankton and cladocerans.

Materials and methods

Plankton samples have been collected since 1945 at least monthly, generally every 7–10 days, in depth profiles from the surface to 250 m at a single main station (Point #1) in the Southern basin approximately 2.2 km offshore from Bol'shie Koty (51° 54',195 N и 105° 04',235 E) where water depth is approximately 900 m. This site is typical for the open Baikal and seasonal and interannual dynamics of ecosystem components here is in good accordance with the rest of the lake (Kozhov, 1963; Kozhova & Izmest'eva, 1998). Thin ice prohibits collection in some months, usually January. Water temperature is measured using a mercury thermometer in samples retrieved on deck with a Van Dorn bottle. Secchi depth is routinely measured as an index of water quality.

Discrete depths of 0, 5, 10, 25, 50, 100, 150, 200 and 250 m are targeted for measurement of abiotic variables and sampling of phytoplankton with a 10 L Van Dorn bottle. Until 1973

phytoplankton samples were fixed with formalin, after 1973 – with Utermohl solution. Phytoplankton samples are enumerated at the species level.
Single zooplankton samples are collected with a closing plankton net (37.5-cm diameter, 100-µm mesh) from depth layers of 0–10, 10–25, 25–50, 50–100, 100–150, 150–200 and 200–250 m. Zooplankton samples have been fixed and stored in formalin throughout the long-term monitoring program. Zooplankton samples are enumerated at the species level and also identified by age class.
We've used zooplankton data for 1961 – 2010 (50 years). Diatom phytoplankton analyzed for 1950-2010, non-diatom – for 1975-2010 (as tiny forms of phytoplankton could not suffer fixing with formalin). For biological data, we averaged data within the top 50 m of the lake, the portion of the water column containing the summer thermocline and the most of the plankton organisms.

Results
Phytoplankton community of the lake consists of two well distinguished complexes: under-ice complex, formed by large-cells diatom endemic species, and summer complex, composed from small-cells cosmopolitan forms. They are characterized by high frequency of occurrence, frequency of dominance and their number can be extremely high. Here we can observe long-term dynamics of 3 principal species from each complex (fig. 1). The well seen trends we can observe for *Aulacoseira baicalensis* and *Monoraphidium pseudomirabile* (Korschik.) Hindak et Zagorenko – representatives of both complexes under study.
The results of zooplankton number dynamics (fig. 2) demonstrate the following. There is some tendency for increase of total number of zooplankton (both maximal numbers and yearly averaged), possibly connected with the rise of number of dominant zooplankton species (presenting up to 95% of total zooplankton number and biomass) – *Epischura baicalensis* Sars. Analysis of number of both Cladoceran species met in Baikal shows expressed trends of rise of their number.

Discussion
We have analyzed the consequences of anthropogenic influence on the lake ecosystem with mathematical model, taking into account input of nutrients, toxic and non-toxic compounds at the level of end of 1980th – beginning of 1990th years, when industry and agriculture were more powerful than they are now. According to predictions of this model (Silow et al., 1995; Silow, 1999; Silow et al., 2001) we can wait for decrease of biomass of under-ice phytoplankton and increase of summer phytoplankton, increase of summer zooplankton. These predictions were supported by observations of 1990-2000th (Hampton et al., 2008; Izmest'yeva et al., 2011).
We can see that summer phytoplankton complex species, some of them demonstrating positive trends of the numbers, are characterized by small biovolumes (from 10 to 150 µm^3). It is in good concordance with the data of other researchers, who demonstrated the gradual increase of the share of small sized alga connected with Global Change.

A B

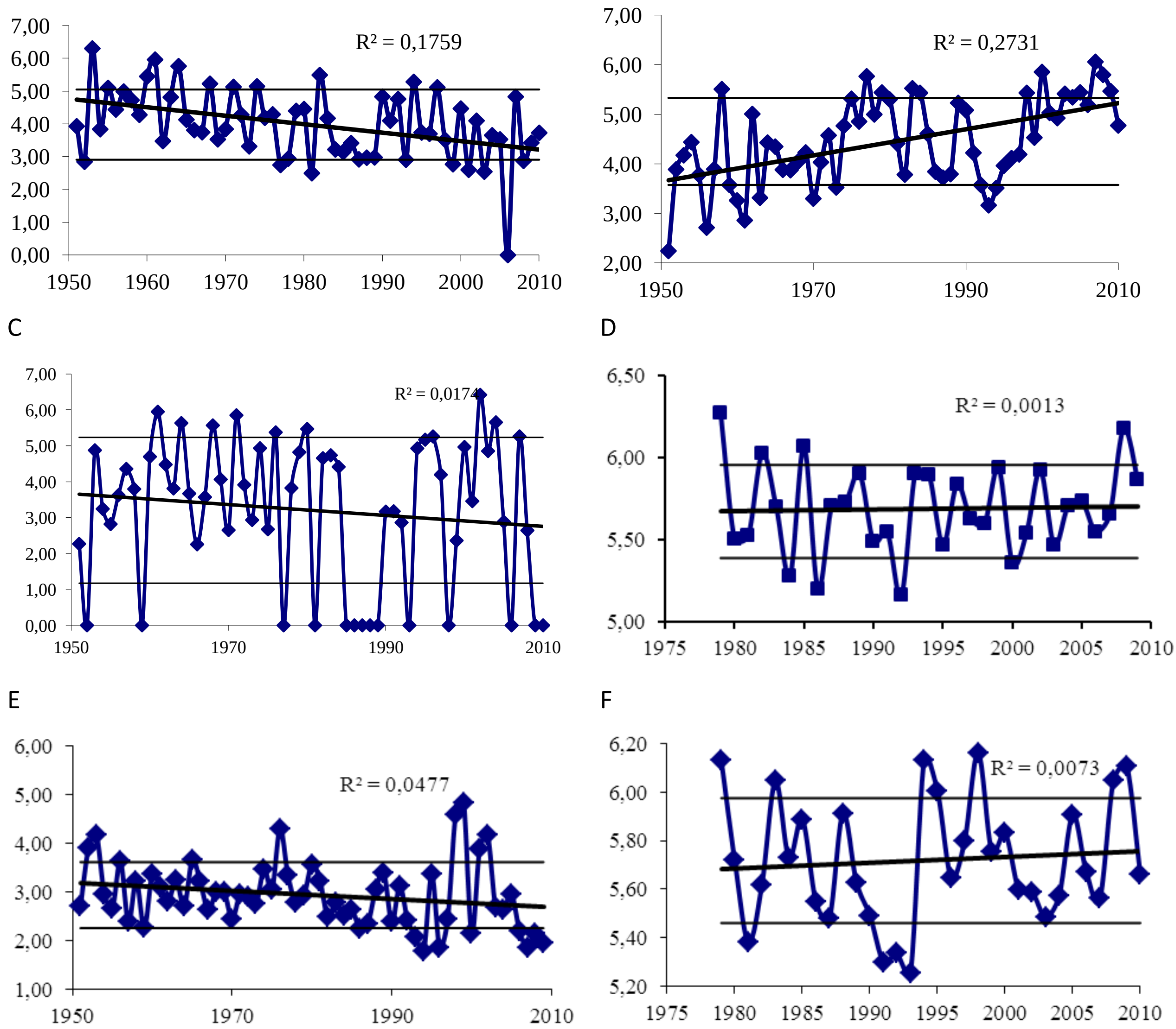

Fig. 1. Long-term (1951-2010) variability of alga number (lg cells l^{-1}) in Baikal. Horizontal lines – average + and – standard deviation, bold line – linear trend. A – *Aulacoseira baicalensis*, B – *Monoraphidium pseudomirabile*, C – *Stephanodiscus meyerii*, D – *Chrysochromulina parva*, E – *Cyclotella baicalensis*, F – Rhodomonas pusilla

It is necessary to note, that global climate change causes decrease of share of large-cells phytoplankton, increase of share of small-cells phytoplankton, mass development of some groups of zooplankton (cladocerans). All of these processes are described for Baikal (Izmest'yeva et al., 2011; Izmest'yeva, Silow, 2010; Moore et al., 2009; Pislegina, Silow, 2010; Shimaraeva et al., 2010; Silow, 2010).

We must stress the predicted consequences of chemical pollution of the lake and possible shifts caused by climate change are practically the same. In both cases we await the growth of small-cells phytoplankton share, strengthening of summer phytoplankton, cladocerans and cyclops development. The picture observed coincide with this. So, today we can't select one of the explanations of observed picture – is this consequence of local and regional anthropogenic

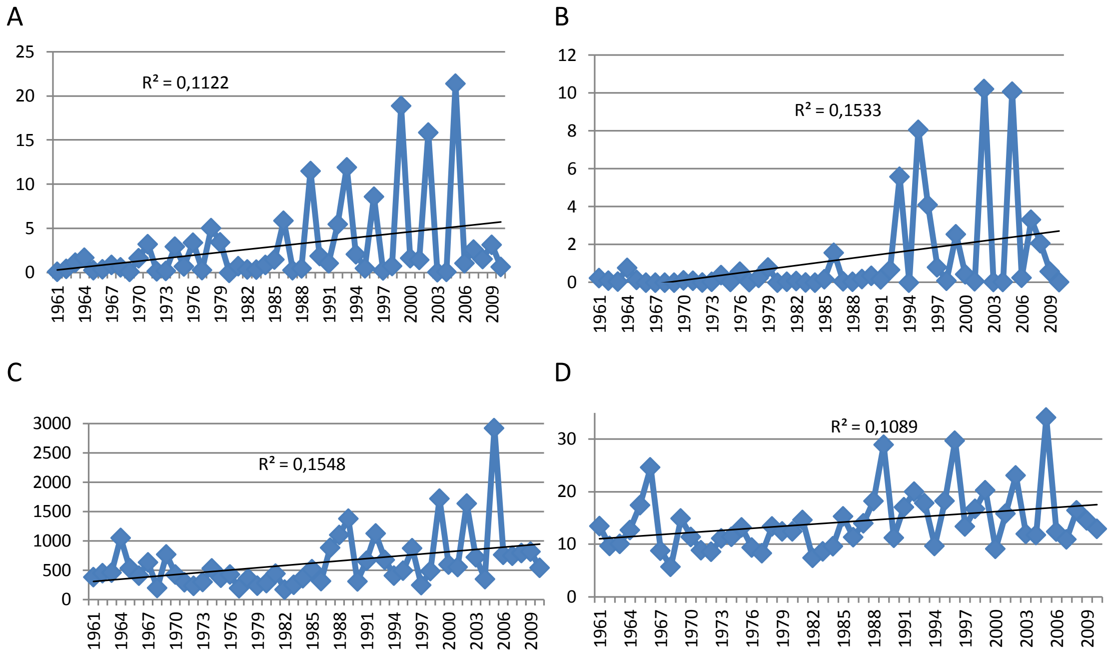

Fig. 2. Long-term (1961-2010) variability of maximal zooplankton number (10^3 specimens m^{-3}) in Baikal. A – *Bosmina longirostris*, B – *Daphnia longispina*, C – total zooplankton, D – yearly average data for total zooplankton

impact in the form of pollution, the result of global climate change, or the effect of natural oscillating processes.

These trends can be explained by:

1) Global Climate Change (though temperature of the lake shows long-term oscillations).
2) Regional Warming (due to building of reservoirs system in 1950s-1970s).
3) Local Chemical Pollution (due to industrial and agricultural activity in watershed and airshed basins of lake).
4) Natural Oscillating Behavior of Plankton Components.

Acknowledgements

Current research was supported by Russian Ministry of educations and science, research project № GR 01201461929.

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A non-homogeneous Markov model for the definition of climate change scenarios for coastal areas: the case of the Agro-Pontina plain

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Keywords: Climate Change, Statistical downscaling, Hidden Markov Model (HMM), Nonhomogeneous Hidden Markov Model (NHMM)

Introduction

The development of climate change scenarios, particularly for critical regions, such as the Mediterranean, is becoming very important for the definition of strategies to predict climate change impacts on the physical environments. Usually, global climate change predictions are built through Global circulation models (GCMs), important tools in the assessment of climate change but coarse in spatial resolution and so unable to resolve significant sub-grid scale features. Therefore, for assessing the hydrological impacts and so to bridge the gap between the resolution of GCMs and local scale processes, different downscaling techniques, based on the identification of statistical relationships between large-scale features and local precipitation, are carried out. So, in this study, an analysis of the possible changes in Agro-Pontina plain (Italy) rainfall under different global warming scenarios for the 21st century is proposed. Hence, the "weather typing schemes", hidden Markov Model(HMM) and non-homogeneous hidden Markov Model(NHMM), are used as statistical downscaling tools which relate the occurrence of weather states to local climate according to their synoptic similarity. Usually, NHMM is used to simulate daily precipitation at specific period of the year but this selection prevents an assessment of possible seasonal changes resulting from the global climate changes. The idea is to construct a model able to capture the seasonality of precipitation using particular large scale atmospheric predictors which affect the local rainfall regime.

Materials and methods

The study concerns a coastal area of Central Italy, the Agro-Pontina plain which is a relevant example of reclamation region and presents the typical hydro-geological features of Mediterranean coastal environments. It is densely populated and is the site of important agricultural and industrial activities. In the context, climate changes, particularly subsequent changes in hydrologic cycle, could be a hazard and adversely affect the sustainability, the future socio-economic development of the area and the biodiversity heritage of the National Park 'Circeo'. For this reason, an analysis of the actual and future precipitation features on

Agro-Pontino plain is proposed. Here, given past success with these models in a similar setting, a HMM and a NHMM are developed using a 54-years record (1951-2004) of daily rainfall amount at 7 stations in Agro-Pontino-plain ("Istituto Idrografico e Mareografico di Roma" and "Areonautica Militare") and re-analysis atmospheric fields of Geo-Potential Height and Temperature at 1000hPa, Meridional & Zonal Wind at 850hPa and Precipitable Water ("NCEP/NCAR" - http://iridl.ldeo.columbia.edu/).

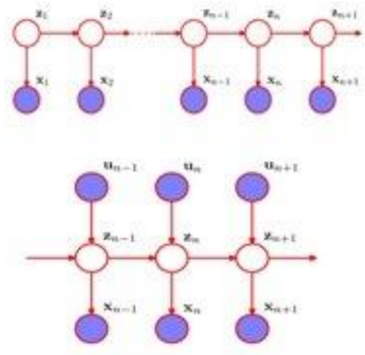

Fig. 1. Graphical representation of NMM and NHMM models

In HMM model rainfall occurrence and amount are governed by a few discrete hidden states, with Markovian daily transitions between them (Hughes & Guttorp (1994); Robertson et al. (2004)). Instead, in NHMM model, HMM transition probabilities are allowed to vary with time, as a function of large scale atmospheric variables, exogenous predictors (Abedalrazq et al. 2010, Kwon et al. 2009). In environments studies, NHMM models have found widespread application in meteorology and hydrology, in studies of climate variability or climate change, and in statistical downscaling of daily precipitation from observed and numerical climate model simulation. In the recent past, NHMM has been successfully used to downscale precipitation in different region of the world (Robertson et al.(2004); Charles et al.(1999), Hewitson & Crane(2006), Cioffi et al.(2014)) and it is able to reproduce key characteristics of precipitation such as inter-annual variability, occurrence and persistence of wet and dry spells at individual sites, and correlation between precipitation series for pairs of sites (Hughes & Guttorp(1994); Charles et al.(1999)).

NHMM was used for a selected season but this prevents an assessment of possible seasonal changes so, here, the whole year is considered to capture the precipitation seasonality using particular large-scale atmospheric predictors which affect the local rainfall regime.

At first, to identify daily rainfall characteristics and variability, HMM is used to identify a number of hidden states of daily rainfall occurrence using observations of the 7 stations for 1951-2004.

NHMM is applied to relate hidden states to daily large scale predictors selected and extracted from the NCAR-NCEP re-analysis dataset for a selected domain.

The averaged composite is constructed for each predictor, from the daily fields corresponding to a particular state of the HMM "Viterbi" sequence.

Atmospheric variables were reduced by computing the principal component analysis and subsequently used as predictors for NHMM.

Then, through NHMM, Calibration(1951-1994) and Validation(1995-2004) tests are carried out in order to select the best combinations of predictors and to construct a reliable predictive tool able to link the statistics of local daily rainfalls in Agro-Pontina to large-scale atmospheric patterns.

Results

The aim was the construction of a model able to capture the seasonality of precipitation using particular large scale atmospheric predictors which affect the local rainfall regime.

This goal has been reached, infact daily rainfall variability is described in terms of occurrence of 5 hidden weather states identified by the HMM and associated to variables representing the main characteristics of large scale atmospheric circulation as obtained by reanalysis data. Moreover, the averaged composite fields associated with each hidden state from HMM capture the main seasonal characteristics of large scale climatology affecting Agro-Pontina. Then, the calibration and validation tests, for different predictor combinations, reveal the effectiveness of the NHMM for the conditional simulation of the rainfall occurrence and amount statistics. Also, from NHMM analysis, the optimal set of predictors to reproduce better the observed seasonal rainfall features on Agro-Pontina is identified (Geo-Potential Height and Temperature at 1000hPa, Meridional & Zonal Wind at 850hPa and Precipitable Water). The following figure shows a good comparison between the total observed rainfall amount and NHMM simulations in a monthly basis for the optimal predictor combination which gives the most accurate reproduction of seasonal rainfall regime of Agro-Pontina.

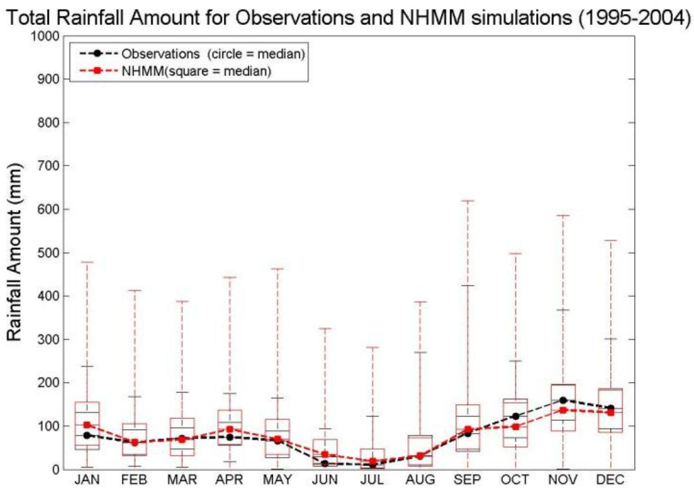

Fig. 2. Comparison between monthly median of observed and simulated from NHMM for the best predictor combination selected for the period 1995-2004

Discussion

An exploration of NHMM potentiality to be used as predictive tool for precipitation has been carried out. The results reveal the suitability of the NHMM for the conditional simulation of the rainfall occurrence and amount statistics and particularly it can be considered as a

diagnostic model to identify the link between observed daily rainfall in Agro-Pontina and large scale atmospheric variable as obtained from reanalysis data.
In the next future NHMM will be run to make future projections of the downscaled precipitation as by using the GCMs simulations under different global warming scenarios.

Acknowledgements
The authors are grateful to the "Istituto Idrografico e Mareografico di Roma", "Areonautica Militare" and “NCEP/NCAR” for providing daily rainfall datasets and re-analysis data respectively.

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High Altitude Himalayan Lakes and Biotic Response to Global Environmental Change

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Keywords: High altitude, Himalaya, lakes, climate change, chironomids

Introduction

Climate change is overriding all other environmental issues, and in particular is true and relevant for a country like Nepal with its prime location in the Central Himalaya. The geological process of continental collision is still active in the Himalayan region causing gradual or sudden erosion. The chemistry and biology of the lake sediments for this reason is important and mainly determined by weathering phenomenon of rocks in the watersheds (Tartari *et* al. 1998). Many of the studies performed in high altitude lakes in Sikkim and Kashmir (Zutshi 1991, Khan and Zutshi 1980, Sharma and Pant 1979) indicated very low concentration of dissolved nutrients and minerals and also indicated by limited growth of phytoplankton. Lake Gokyo was studied for three years (2008-2011) to understand its morphology and limnology, the detailed account of its morphometric features, environmental conditions and the biodiversity of diatoms is published elsewhere (Sharma *et* al. 2011, Juettner *et* al. 2010). The main objective of this study is to compare heavy metals in water and sediments from high altitude Himalayan lakes, and response of non biting midges (Insecta: Chironomidae) to global environmental change based on sub fossil remains of the head capsules in the sediments.

Materials and methods

The two studied lakes are named as Gokyo or Third Lake and Gosaikunda (Fig. 1). Lake Gokyo is in the Eastern zone protected by Everest National Park authority and Lake Gosaikunda in the Central zone under Langtang National Park, but both are considered high altitude lakes situated along the Main Himalayan range.

Lake Gokyo is glacial in origin and is believed to be fed by seepage or spill out from Ngozumba glacier besides springs from Renjo La Pass to the north-west. There are four other major lakes in this zone with no direct visual connection to Lake Gokyo, and all belong to the headwaters of Kosi River System. Lake Gosaikunda is snowfed with a perennial source of spring to the north-east, considered a holy place by Hindus and Buddhists. There are many lakes in the series connecting Lake Gosaikunda that fed river Trisuli in the Gandaki River System.

Fig. 1. Location map of the study area (not in scale). Photo in portrait size is Lake Gokyo, (Mt. Everest National Park) and in landscape is Lake Gosaikunda (Langtang National Park)

A GPS (Garmin Venture SC) in tandem with Ecosounder model PLASTIMO ECHOTEST II were used to find the deepest part of the lakes, the data were later compiled using GIS software to draw bathymetric maps.

Two core samples were collected from Gokyo lake and one from Gosaikunda lake, cut at 0.5 cm slices, and transported in an ice box. Additionally a 5 cm depth sediment samples was collected from the littoral zone of Gosaikunda lake only using a core of Ø 50 mm and designated as GK1-GK5. GK1 is site used frequently for bathing by the pilgrims to the west, GK2 is where inlet (Trishul dhara) meets the lake, GK3 and GK4 are East and Southern corner of the lake respectively and GK5 is close to the outlet of the lake.

Sampling sites were selected at five locations such as middle of the lake, deepest part, inlet, outlet, and when any visible impact is observed - at the human impact site. Temperature, oxygen, pH were measured along the vertical profile using Orion Star Series Multimeter Test Kit, and transparency using a Secchi disc. UWITEC water sampler (with a built in thermometer and outlet valve, Ø 10cm, height 76cm) was used for water sampling from different depths. Water samples for metal analysis were collected in 100 ml plastic bottles pre-treated with dilute HNO_3.

Extraction of head capsules from sediment samples was done following the standard procedure outlined in Walker (2001) for air dried sediment samples with slight modifications. Identification was performed with reference to Roback and Coffmann (1987), Walker (2007), and Brooks et al. (2007) under a compound microscope (400×).

Results

Metal concentration in sediment samples

The result of the heavy metal concentration in the collected sediment samples from Gosaikunda lake in May 2010 is as shown in Table 1. The concentration of Iron is very high and varies from 594,000 ppm in the sample collected below the Trisul dhara (one of the major inlets to the lake Gosaikunda) to 9,894 ppm in the sample collected from the northern part of the lake. The other heavy metals like Cd, Cr, Cu, Pb, Mn, Zn, and Ni were also detected in the sediment sample collected.

S.N.	Sample Code	Analyzed Parameters				
	Parameters (ppm)	GK1	GK2	GK3	GK4	GK5
1.	Cadmium (Cd)	0.8	1.3	0.8	<0.5	<0.5
2.	Chromium(Cr)	<1	<1	<1	9.2	10.3
3.	Copper (Cu)	92	262	27	57	9
4.	Iron (Fe)	28670	594000	27120	110200	9894
5.	Lead (Pb)	68.7	98.2	23.1	41.8	33.4
6.	Manganese (Mn)	205	1407	108	116	38
7.	Nickel (Ni)	31	78	36	39	14
8.	Zinc (Zn)	69	177	93	86	36

Table 1. Metal concentration in the sediments of lake Gosaikunda (May 2010)

Metals concentration in water samples:

Cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc levels were analyzed in the water samples collected from the Lake Gosaikunda in May 2010 (Table2). Results revealed most of the analyzed metal concentrations below thelevel recommended by the WHO for safe drinking water except Pb that measured 0.025 mg/L. Lead (Pb) and cadmium (Cd) levels exceeded the limits also in the lake Gokyo in some of the samples creating concern for human health.

Chironomid Analysis

The abundance of chironomids varies at different sampling sites along the Littoral zone. It varies from 467 in sample site GK4 to 52 in sample site GK1 in Gosaikunda lake. The sediment sample from the site GK1 is characterized by an abundance of the Tanytarsini. Of all the 5 randomly selected head capsules from this site, all were Tanytarsini from sub family Chironominae. The sediment sample from the sample site GK2 and GK3 is characterized by an abundance of the Diamesinae and Orthocladiinae with *Pseudodiamesa spp* and *Rheocricotopus spp* identified up to the genus level. The sample site GK4 and GK5 is characterized by an abundance of the Orthocladiinae. In total, the sediment sample from the lake is mostly characterized by an abundance of the Orthocladiinae and Diamesinae. The samples were collected from the littoral zone and this zone tends to be dominated by the Orthocladiinae (Brooks *et* al., 2006). The abundance of the Orthocladiinae, Diamesinae and Tanytarsini classifies this lake as an oligotrophic lake.

Discussion

The correlation between heavy metals and chironomids abundance shows that heavy metals like chromium, manganese, cooper, lead, nickel, zinc and iron except the cadmium shows the negative correlation to the chironomids abundance. Statistically, chromium shows the negative correlation with chironomids abundance. Lake Gokyo consist mostly the subfamilies of Chironominae and Orthocladiinae followed by Diamesinae. The Diamesinae is composed of the genus *Pseudodiamesa*. The Chironominae are represented by the genus *Micropsectra*, and Orthocladiinae by *Orthocladius/Cricotopus* – type and *Eukiefferiella/Tvetenia*-type. *Rheocricotopus* sp. of the subfamily Orthocladiinae were also found in both the cores sampled.

Acknowledgements

The research was supported in part by Aquatic Ecology Centre, WWF/Nepal, Fulbright Commission/USA and OEAD/ Austria.

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Temporal changes in ionic composition of lakes in the Eastern Alps

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Keywords: major ions, lakes, permafrost, rock glacier

Introduction

The chemical composition of lake water is the result of the mutual dynamic interaction of climatic, hydrological and geological factors and is often also influenced by human activities. The average major ions composition usually remains approximately constant unless severe modifications within the watershed or of the climate occur. Long term studies allow tracking of the temporal development, particularly interesting in relation to the ongoing climatic changes.

A long term monitoring of the lakes in South Tyrol, a province of the Eastern Alps in Northern Italy, involved lakes from valley bottom to high mountain altitude. A first, dramatic, change in the major ion composition was detected in 2000 for Lake Rasass, a high altitude lake, where a sudden tenfold increase of the solute concentrations where observed (Thies et al., 2007; Ilyashuk et al., 2014). This finding prompted further investigations.

Methods

The monitoring, started in 1979 and included lakes located at elevations between 215 and 2900 m above sea level. The lower lakes were sampled from two to six times a year, whereas high altitude lakes were sampled at much lower frequency and with irregular time intervals. The area of the investigated lakes ranged between 0.01 and 620 ha.

Data elaboration was based on the ionic concentration of inlets and creeks and on depth averaged concentrations for the lakes. Statistical analysis involved mainly frequency distributions and cluster analysis of the major ions. Furthermore, in order to investigate the potential effect of climate change, a comparison between data collected before and after 2000 was made.

Results

The ionic composition of the majority of the monitored lakes shows negligible temporal changes. In particular, sulfate concentrations in high altitude lakes are generally lower then in the recent past due to the decreased sulfur level in the atmospheric precipitation of the last years. Despite this fact, the ionic concentration of sulfate, magnesium and calcium of some water bodies has rapidly increased during the last two decades, while leaving the alkalinity level practically unchanged. These temporal changes are also accompanied by seasonal fluctuations which are more readily evident in the creeks than in the lakes themselves (Fig. 1).

The distribution of average sulfate, magnesium and calcium concentrations of more than 200 surface waters above 1600 m altitude showed that only few lakes have so high concentrations of these three solutes that they fall distinctly outside the normal distribution curve (Fig. 2).

These lakes proved to be nearly exclusively high altitude lakes with watersheds dominated by crystalline basement rocks. Similar chemical modifications, albeit at lower level, could also be observed in some downstream located surface waters as some lakes, creeks and hydropower plant reservoirs. In few cases drinking waters used for the water supply of high altitude refuges were also found to be affected.

To investigate the influence of the observed phenomena a cluster analysis was applied to the dataset of lake water compositions. The analysis was performed on mean concentration values obtained after the year 2000 for lakes located at all altitudes. The clustering identified five groups of lakes, the smallest of them containing the three lakes most influenced by rock glaciers (Table 1). These three lakes are geographically located in the western part of the province, where crystalline rocks prevail. Although likewise interesting in this respect, changes in nitrogen concentrations, recently increasing in atmospheric depositions, are difficult to follow because they can be quickly masked by the changes they induce in the primary production.

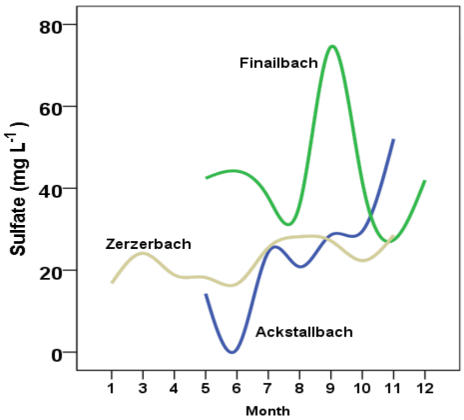

Fig. 1. Seasonality of sulfate concentrations in three creeks (mg L^{-1})

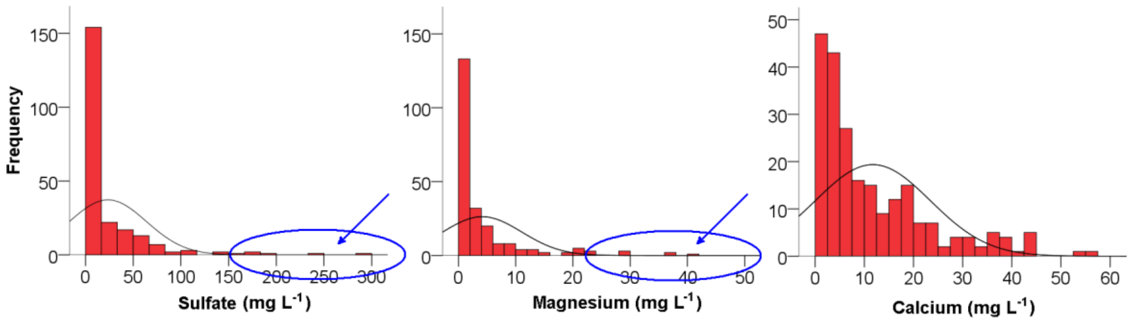

Fig. 2. Frequency distribution of average sulfate, magnesium and calcium concentrations after year 2000 in surface lakes above 1600 m altitude

Group	Alk	Ca^{2+}	DRSi	Mg^{2+}	SO_4^{2-}
Group 1 – low concentration of ions with silica	0.126	0.226	1.152	0.062	0.194
Group 2 – low concentrations of ions and low silica	0.236	0.247	0.439	0.086	0.126
Group 3 – high alkalinity, low sulfate (dolomitic lakes)	2.158	1.255	0.413	0.821	0.153
Group 4 – low alkalinity with sulfate (many of the lakes in this group are partially influenced by rock glaciers)	0.634	0.720	2.220	0.320	0.507
Group 5 – high sulfate, magnesium and calcium with various alkalinity (contains the three lakes most influenced by rock glaciers)	3.330	2.531	2.337	2.202	1.922

Table 1. Groups of lakes identified by hierarchical cluster analysis (method Ward, indices, DRSi = dissolved reactive silica)

Discussion

The observed increased ionic concentrations in some high altitude lakes are too high to depend only on enhanced weathering driven by climate warming, since the watersheds of these lakes are mostly small and the water travel time is short. It is assumed that the main driving factor for the observed changes is the melting of rock glaciers which were detected within all the watersheds where the increase in solute concentrations was observed. Increased ionic concentrations of surface waters were observed also in other studies of rock glacier areas (Williams et al., 2006; Thies et al., 2013).

Rock glaciers, a mixture of ice and rocks flowing like a glacier, are a very common feature of mountain permafrost areas. Climatic models forecast for the Alps a warming of about 4°C between now and year 2100 and therefore a significant melting of the permafrost can be expected. The high concentrations of solutes, mainly sulfate, magnesium and calcium in the outflow of the rock glaciers are produced by chemical, physical and biological processes taking place within them (Giardino, 1992; Williams, 2006; Sonnleitner et al., 2011; Manning, 2013). Hydrological features also play an important role) (Krainer & Mostler, 2002). The final products of these processes and the concentration level of the outflowing solutes, which in some cases also include heavy metals like nickel, aluminum and manganese, seem to depend on the lithological composition of the rock glacier itself. A comparison between data collected before and after year 2000 evidenced which lakes are probably influenced by rock glacier to various degrees.

Mineralogical investigations of the watersheds containing rock glaciers will predict what changes in the chemical composition of their surface waters are to be expected and also identify the regions where heavy metal enrichment could cause toxicity problems to the drinking water supply.

The extent to which the observed chemical modifications are reflected on the biotic components is part of the running Interreg IV Italy-Austria (2011-2014)-project “permaqua”.

Acknowledgements

These investigations have been partly co-financed by EU-projects (Step, Alpe, Molar, Emerge) and presently by the Permaqua Interreg-project.

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INFORMATICS, MAPPING AND MONITORING

Enumeration of benthic animals in a deep lake using a ROV

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Keywords: underwater robot, benthos, Lake Biwa, video camera

Introduction

It is not easy to enumerate benthic animals on the bottom of a deep lake. Sediment grab samplers and fishing nets like dredges have been commonly used to take samples (Downing & Rigler 1984; Haahtela 1978). However, sediment grab samplers cannot take a large sample and dredging nets do not always extend to the bottom because of boat rolling. Therefore, high accuracy data remains a need for ecological analysis. Recently, observation methods using digital images with an underwater robot have been developed (Kumagai 2006; Ishikawa & Kumagai 2014). In this study, a ROV (a remotely operated vehicle) was improved to enumerate benthos on lake bottoms. As a case study, the benthos monitoring methods using the ROV, a fishing net and a sediment sampler were compared in Lake Biwa, Japan. Recently, ongoing warming and hypoxia in Lake Biwa has threaten benthic animals, including endemic species, living in the profundal zone (Ishikawa 2012) so accurate biological monitoring has been demanded.

Methods

Improved ROV for enumeration

A commercial ROV (DELTA-150, Qi Inc.) equipped with a front video camera easily provides an underwater view allows observations of benthic animals on a lake bottom as well as planktonic and nektonic animals in water. However, front view distance may be limited and variable depending on water clarity, limiting its benefit for scientifc monitoring. In order to enumerate benthic animals, a parallel video camera (Handycam HDR-CX180, Sony) and a pair of lazer pointers as a scalar were attached on a ROV (Fig. 1). In the video images, the length of the two lazer pointers indicate 9 cm with our ROV setting.

ROV benthos monitoring

A ROV observation performed every month from April 2012 to March 2014 at a 90 m (Stas. N4 and HY90) and 70 m depth areas (Sta. Ie). Video images were taken for 30 min at each station. After removing unclear images, benthic animals were identified and counted with naked eye in each image.

Fig. 1. An improved ROV with a parallel camera box for benthos monitoring

Benthos sampling using fishing nets

A fishery trawl net, or dredge, with 1 m wide iron frame was used to take large amphipoid samples eight times between May 2012 and May 2013 at the three stations. Sample collection covered approximetely 200 m^{-2} with each sampling. Benthic animals were collected on a 0.25 mm pore mesh and were identified under a stereo microscope.

Benthos sampling using a sediment sampler
An Ekman grab sediment sampler (15 cm x 15 cm area) was used to take triplicate sediment samples from April 2012 to January 2014 monthly at the three stations. Benthic animals were collected on a 0.25 mm pore mesh and were identified under a stereo microscope.

Results
ROV benthos enumeration
Jessogammarus annandalei, *Asellus hilgendorfi, Palaemon paucidens*, *Bdellocephara annandalei and Branchiura sowerbyi* were detected at the three stations. Minimum (Min) and maximum (Max) densities of these species during the two year research period were 0-1971 ind m^{-2}, 0-224 ind m^{-2}, 0-119 ind m^{-2}, 0-75 ind m^{-2}, and 0-22 ind m^{-2}, respectively. Change of life style for reproduction and sensitivity to oxygen depletion are reflected in their seasonal density variations. Not all of the aforesaid species life cycles or ecological behavior are known. However it is known that juveniles of *J. annandalei* are planktonic (Narita 1976; Ishikawa & Urabe 2005) and *P. paucidens* spawns in the lake shore area (Nishino 1980).

Benthos monitoring with the fishing net
J. annandalei , *P. paucidens* and *A. hilgendorfi* were enumerated at the three stations. Although some *Br. sowerbyi and Stictochironomus pictulus* were collected their bodies were fragmented. Min and Max densities of *J. annandalei* , *A. hilgendorfi* and *P. paucidens* were 0-59 ind m^{-2}, 0-10 ind m^{-2} and 0-3 ind m^{-2}, respectively.

Benthos monitoring by Ekman sediment sampler

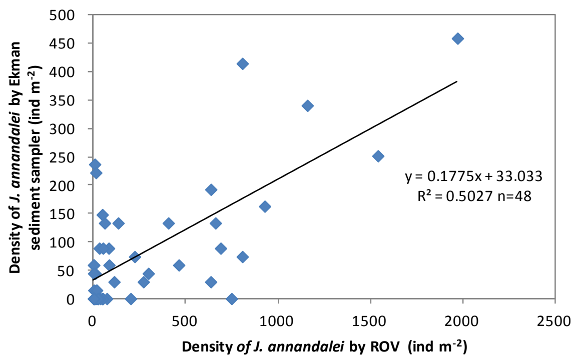

Fig. 2 Relationship between densities of *J. annandalei* obtained ROV and Ekman sediment sampler.

J. annandalei, *A. hilgendorfi, Br. sowerbyi and S. pictulus* were found at all stations. However *P. paucidens* was not collected because they escaped quickly and *Bd. annandalei* was not enumerated because of its low density.
Min and Max densities of *J. annandalei* , *A. hilgendorfi, Br. sowerbyi and S. pictulus* were 0-459 ind m^{-2}, 0-444 ind m^{-2}, 44-459 ind m^{-2} and 0-341 ind m^{-2}, respectively.

Discussion

There was a correlation between the density of *J. annandalei* obtained by ROV and Ekman sediment sampler (Fig. 2) at the three stations. Density was underestimated using the Ekman sediment sampler compared with that by ROV. One possible explanation is that *J. annandalei* escaped from the Ekman sediment sampler because they can move quickly. On the other hand, *J. annandalei* was visible via the ROV video camera and there is no doubt that they were present in large numbers.

There was no relationship between the density of *J. annandalei* estimated with the fishing net and ROV or Ekman sediment sampler. In addition, the density obtained with the fishing net was much smaller than with either the ROV or Ekman. It was confirmed with a depth sensor attached to the net that the dredge did not always extend to the bottom because of boat rolling.

It is not easy to enumerate benthic animals in a deep lake because equipment, including research boats, have not been specifically developed for the task so few or little historical biological data are available. However, *J. annandalei* had the greatest benthic biomass in Lake Biwa. The significant difference among monitoring methods for the ecological studies is a serious problem that needs to be addressed.

Therefore, we recommend the following monitoring methods for particular benthic animals in Lake Biwa (Table 1):

Table 1. Benthic animals in the profundal zone of Lake Biwa estimated by different monitoring methods

Living conditions	Species	Fishing net	Ekman	ROV
On the bottom	Jessogammarus annandalei			Good
	Palaemon paucidens	Good		Good
	Asellus hilgendorfi	Good	Good	Good
On / In the bottom	Bdellocephara annandalei			Good
	Branchiura sowerbyi		Good	Good*
In the bottom	Stictochironomus pictulus		Good	

* the case *B. sowerbyi* on the bottom

ROV is the method of choice for most benthic animal monitoring in Lake Biwa. It is important that appropriate monitoring methods are chosen for target species. Future improvements in sampling technology will help researchers. For example, at this time the ROV cannot evaluate organisms in the sediment, only on it. So the next improvement step is how to collect sediment samples.

Acknowledgements

This research was supported by a Lake Biwa Environmental Research Institute research grant for a “Study on the hypolimnetic waters and bottom environment in the North Basin of Lake Biwa”.

We thank the crews of R/V Hakken for field assistance.

A WLC-15 presentation grant was provided by the Japan Science Society.

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Contribution of the Limnology Institute of Russian Academy of Sciences to the development of information systems in limnology

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Keywords: information systems, lakes, regional lakes, water resources

Introduction

The progress of limnological science has led to the establishment and development of different kinds of lake databases providing necessary information on the quantity and quality of surface waters. The first databases contained only information stored on paper. A tremendous technological leap brought on by the invention of computers, and the ensuing computerization of all areas of expertise, made it possible to move from the simplest databases on to complex information systems.

At the Limnology Institute of RAS data on the lakes of the world has since the late 1980´s been collected by a group of experts led by S.V. Ryanzhin (Ryanzhin et al., 2001). They created the WORLDLAKE database which today contains various data on more than 60,000 lakes and reservoirs. However, the work on the development of databases intended for a wide range of Internet users was initiated only in the early 2000's. To provide geographical science with information resources three information systems ("Lake Ladoga", "Lakes of the Earth" and "Lakes of Russia") have been developed at the Limnology Institute of RAS.

Materials and Methods

The "Lake Ladoga" information system (IS) was developed at the Limnology Institute in 2002-2004 within the framework of a TACIS programme aimed at providing monitoring data on Europe's largest lake Ladoga to a broad audience of users (Kondratiev et al., 2003). Monitoring of Lake Ladoga and the main rivers in its basin is carried out by various organizations. The Limnology Institute of RAS has the longest monitoring records and the most complete monitoring programme. In the northern part of the lake regular monitoring activities have been carried out since 1989 by the Institute of Water Problems in Northern areas of RAS.

The "Lakes of the Earth" information and reference system was created at the Limnology Institute in 2006-2008 within a project run by the Presidium of the Russian Academy of Sciences under the name "Electronic Earth: scientific information resources, information and communication technologies, information service, interaction with national and international systems". This system is a component of the uniform information analysis system GeoSINet (Geographic Science Information Network). Web, GIS and Greed technologies, which were used and developed within "The Electronic Earth" project, enable integration of resources of different types and volumes in the field of geoscience. The "Lakes of the Earth" IS is based on data about large and thoroughly studied waterbodies, mainly lakes and reservoirs (Rumyantsev et al., 2009). Information stored in this system includes the Limnology Institute's own data as well as data obtained from various literary and web-based sources. While the system was being developed, several thousand publications were used and a relevant reference base was established.

Work on the “Lakes of Russia” IS was started in 2010. It became a logical continuation of the "Lakes of the Earth" IS. The most important feature of this IS is the fact that it apart from providing data on the largest lakes in Russia also contains summarized information on lake water resources of the Russian Federation defined by federal districts and federal regions. This information is a result of ongoing work at the Limnology Institute within the framework of the project "The role of space in the modernization of Russia: the natural and socio-economic potential", run by the Presidium of the Russian Academy of Science.

All the three IS were created in the form of domain-driven DW (data warehouses) using modern means of automated processing, including analysis and visualization of data. The interactive facilities of these systems support the functions of data storage and analysis, they are presented in the form of web pages containing menus, forms, text and graphical information. Depending upon the user-selected menu items, it is possible to use different server modules for processing data. For data retrieval and data analysis special software allowing to dynamically generate SQL-queries was developed. The program builds a SQL-sentence by performing a sequence of specific steps forming the sentence, defines the columns and row fetching for return set, and then executes this sentence.

All information contained in the “Lakes of the Earth” and “Lakes of Russia” IS is only submitted in Russian.

Results

The “Ladoga Lake” IS contains the results of monitoring activities which have been carried out by the Institute of Limnology and the Institute of Water Problems in Northern areas of RAS since the 1990’s, including joint activities with Finnish colleagues within the TACIS program. This IS contains data on hydrophysical, hydrochemical and hydrobiological parameters received from the network of stations located in the lake area. It also contains remote sensing data on Lake Ladoga and the Neva Bay of the Gulf of Finland, which are provided by *Nansen International Environmental and Remote Sensing Centre*. Constant monitoring of the thermal regime of Lake Ladoga and the Neva Bay is done with the help of the information provided by NOAA and MODIS. Staff of the Limnology Institute and the International Nansen Centre are working together in order to process and analyze remote sensing data and contact measurements in the relevant water areas.

The system is being continuously replenished with data from new expeditionary research.

The “Lakes of the Earth” and “Lakes of Russia” IS both provide literature-based information on the most important and well-investigated water bodies. Both systems contain formalized information (stored in databases and available on request) as well as large amounts of texts, charts, graphs, pictures with links to the sources of information.

Both systems are organized in a way enabling the user to choose his waterbody of interest on the home page. Along with the general description of the lake the user can view a dynamically generated menu in the upper right-hand corner, granting access to more specific thematic information upon request to the database. The user can also access non-formalized information about the waterbody, presented as a set of html-files.

The "Lakes of the Earth" IS contains data on 965 lakes of the world, located on all continents (fig. 1).

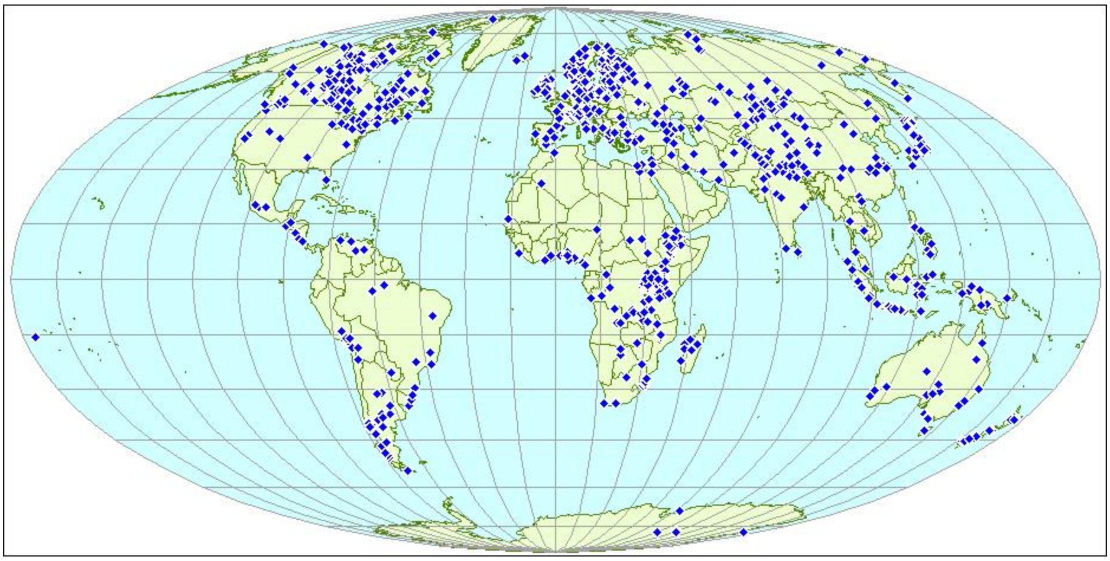

Fig. 1. Distribution of lakes contained in the "Lakes of the world" IS**.**

The "Lakes of Russia" IS contains data on 370 lakes and reservoirs (fig.2). This system includes lakes with a water area of more than 50 km^2, regardless of their limnological exploration degree. Since the “Lakes of Russia” IS remains an open system, it is supposed to be continuously replenished, both due to new information on the water bodies already included in it, and through inclusion of new water bodies.

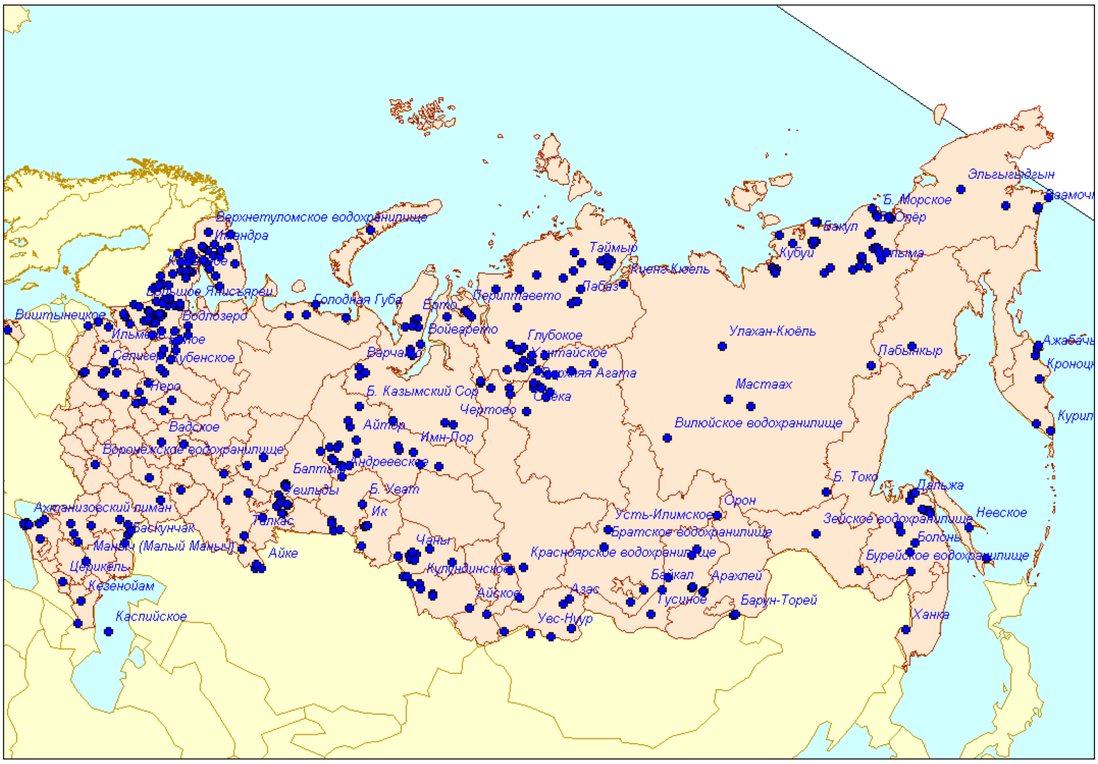

Fig. 2. Distribution of lakes contained in the "Lakes of Russia" IS**.**

In 2012 the "Lakes of Russia" IS was expanded by introduction of a new block, which had been developed for the storage of summarized information on lake water resources of Russian regions. The system comprises a general description of the region, information on its climate, hydrography and limnology. The limnological information includes the number of lakes, the total water surface area, size of lake water resources in volumetric expression. Along with numerical data the IS provides information on the origin of lake basins, on characteristic features of lakes of different origin, on the distribution pattern of the lakes in the region's area. A list of the largest lakes within the area (with references to the State Water Registry) is provided. There are immediate plans to add some data on the ecological status of regional lake water resources.

The developed software allows users to search and process information on lake water resources and provides an opportunity to conduct a comparative interregional analysis.

Discussion

Databases containing descriptive information face serious competition from widely known and publicly available information resources such as Wikipedia. It is therefore more appropriate to create expert-based IS providing unique observational data, calculations and generalizations made at a proper scientific level. Among the systems created at the Limnology Institute of RAS, the "Lake Ladoga" IS, which provides users with regular observation data still attracts the most attention. The development of a new block of the "Lakes of Russia" IS, complementing the existing reference system with information containing scientific generalizations and results of actual calculations, seems also very promising.

All IS created at the Limnology Institute are undergoing constant development and updating. All the systems are available on the website of the Limnology Institute of RAS http://www.limno.org.ru .

Acknowlegments

Thanks to T. Ulianova as the main developer of databases at the Limnology Institute of RAS, and to the administration of the Institute for their support in the development of information systems.

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Database of the International Data Centre on Hydrology of Lakes and Reservoirs

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Keywords: observations, database, hydrology, lakes and reservoirs

Introduction

The International Data Centre on Hydrology of Lakes and Reservoirs (HYDROLARE) is hosted by the State Hydrological Institute (SHI, St. Petersburg, Russia). It was established at the initiative of the SHI under the auspices of WMO and Roshydromet and has been in operation since 2009. The key function of HYDROLARE is establishment and managing a database on hydrology of the world's lakes and reservoirs.

Background

The concept of the HYDROLARE database includes collection, archiving and provision to users in accordance with WMO principles of the main annual characteristics of lakes and reservoirs for the period since the beginning of observations until past year with further annual update of the data. The main characteristics include mean and extreme water levels, temperature and ice cover thickness.

Up to now water level has been the most priority type of data to include in the database. Initially the database was built up on the archive of the Water Cadastre of the USSR and Russia containing current observations on lakes and reservoirs of the USSR and an electronic archive of long-term lake and reservoir regime data for 697 water bodies and 1242 stations.

In order to start the process of collecting data from other WMO Members, a special questionnaire was circulated to these countries. 14 countries responded to the questionnaire. Due to a variety of data submission forms (different file content, structure and formats, databases and web pages of more complicated structure), it required an extensive preliminary analysis and preparation of the provided data. Water bodies and stations were coded using a unified system, data were referenced to unified coordinate systems and units of measurement, and also some structural and format transformations were made enabling download of the data to the database. Some data were searched and identified on the web sites of providers.

Results

The database currently contains different types of level data for lakes and reservoirs of 17 countries (863 stations, 588 water bodies). These are mainly presented by data for Russia and 11 former USSR States. This dataset includes data from 459 stations on 297 water bodies of Russia and 331 stations on 206 water bodies of the former USSR States. These water bodies include the largest lakes of the European Russia such as Ladoga, Onega, Ilmen and the largest lake of Siberia Baikal, as well as the largest in Kyrqyzstan Lake Issyk Kul. The rest comprises data for Finland (36 stations on 36 lakes with surface area more than 100 sq km and length of time series more than 100 years, including the system of lakes Saimaa, the fourth largest fresh water lake in Europe), Switzerland (34 stations on 26 water bodies, including Lake Geneva, the second fresh water lake in Central Europe), Cyprus (18 reservoirs, including Kouris, the largest reservoir of Cyprus, with capacity of 115 million cubic m), as well as the fresh water systems of the North America (five Great Lakes and Lake St. Clair are the largest fresh water accumulation on the Earth). Periods of observations are substantially different for different countries. End years of observation periods are within the range of 1988 to 2013 (see Table 1). Information on the status of the database is published in the annual HYDROLARE Newsletter. Regularly updated information on the status of the database content is available on the web site at: www.hydrolare.net.

Country	**Levels at stations**	**Mean monthly levels for water bodies**	**Levels for water bodies at the first date of each month**
Armenia	1938 – 1988	1938 – 1988	1938 – 1988
Belarus	1901 – 2009		
Cyprus		2010 – 2012	2010 – 2012
Estonia	1921 – 1988		
Finland	1847 – 2013		
Georgia	1928 – 1988		
Kazakhstan	1934 – 2008	1934 – 2008	1934 – 2008
Kyrgyzstan	1927 – 2012	1958 – 2012	1958 – 2012
Latvia	1925 – 1988	1978 – 1988	1978 – 1988
Moldova	1955 – 2010	1968 – 1988	1968 – 1988
Russian Federation	1859 – 2012	1914 – 2012	1914 – 2012
Slovenia	1954 – 2010		
Switzerland	1856 – 2012		
Turkmenistan	1952 – 1989		1958 – 1989
Ukraine	1933 – 1988	1952 – 1988	1952 – 1988
United States of America		1918 – 2012	1860 – 2000
Uzbekistan	1946 – 1988	1959 – 1988	1959 – 1988

Table 1. Time periods of data in the HYDROLARE database

HYDROLARE keeps analyzing data for the large lakes of Sweden, Slovenia (the Bled and the Bohinj Lakes), reservoirs of Mexico and Australia, the lakes of the USA of the Mississippi Basin, as well as some Russian archived data in order to further update its database.

Discussion

In the nearest future it is planned to enhance the database adding remote sensing data provided to HYDROLARE by LEGOS laboratory (France) in the framework of bilateral cooperation. Further update will be made by inclusion of data on water temperature and ice thickness in accordance with the database concept.

In general, one can note both the obvious progress and the challenges related to data collection, supplement and analysis in the process of the database development. Although all permanently populated continents having large lakes or even vast lake regions (Finland, Russia, USA) are presented in the database, there is a number of countries which have not yet provided their data to HYDROLARE, despite the pledges made earlier and numerous requests circulated, and the preparation of data retrieved from national web sites is rather time consuming.

Acknowledgements

The authors express their gratitude to the national services of the WMO Members which provided their datasets on hydrology of lakes and reservoirs to HYDROLARE and are looking forward to regular update of the provided data as well as the response from other Members which have not yet contributed to this international project.

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Investigation of the Caspian sea level variations by the modern methods

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Keywords: Satellite altimetry, Caspian Sea, sea level, in situ

Introduction

Long-term changes in the Caspian Sea level are affected by various factors. The climate and geological factors are the most prominent ones. The influence of climate is usually noticed earlier than the others. The problem of the Caspian Sea level fluctuations has been a reason for various debates and disagreements among scientists over a long period of time. These issues mainly refer to the severe sea level fluctuations observed during the last century (Cazenave, 1997; Kouraev et al., 2011).

Therefore, fluctuation in the level of the Caspian Sea is quite a serious problem and there is a great need for a comprehensive study of its entire sea area. As most of the level measuring stations of the Caspian Sea are located in coastal areas of the sea, their observation of are not able to reflect the processes of the central area. Thus, there is a need for more sophisticated and modern methods for the study of sea-level fluctuations. Especially, the application of satellite altimeter observations is of paramount importance.

Methods and used materials

Data from five satellite altimeters are being used in the study Caspian Sea level fluctuations (Topex/Poseidon, Jason 1-2, ENVISAT and GFO). Satellite's orbit is determined by three positional system: DORIS, GPS and SLR. It is advisable to apply the method of multi-satellite to calculate sea-level fluctuations. But in this case, deviations of data obtained from different satellites have to be taken into account (Mamedov & Gardashev, 2010).

The quality of information obtained from altimeters mainly depends on in-situ observations and calibration of satellite sensors. For this purpose, satellites observing the Caspian Sea were calibrated along their tracks (within ALTICORE project) in 2005-2009. A number of adjustments needs to be taken into account while calculating satellite data. These measures will contribute to the maximum match of altimeter and in-situ data. Thus, it is very important to analyse these two data sources interactively in order to be able to replace in-situ observations with satellite altimeter ones in the future perspective. There are enough number of in-situ observation stations along the perimeter of the Caspian Sea (Figure 1)

The research work includes the comprehensive investigation of the sea level data observed from 1992 to 2011 in currently operating 21 in-situ stations. Moreover, correlation relationships between in-situ observations operating in different parts of the sea have been revealed. This research work refers to the data of the Coordinating Committee for Hydrometeorology and Environmental Monitoring pollution of the Caspian Sea (http://www.caspcom.com) for the in-situ observations. As a source for Satellite data have been used the data from hydroweb organised by CNRS/CNES (http://www.legos.obs-mip.fr). Thise data covers observations from five different satellitest The main purpose of this research is to investigate possible future application of satellite data in sea-level forecasting by carrying out comparative analysis between the data from satellite altimeter and in-situ observation. Correlation relationships have been established among all of the selected ground stations to enable comparative analysis mentioned above (1992-2011).

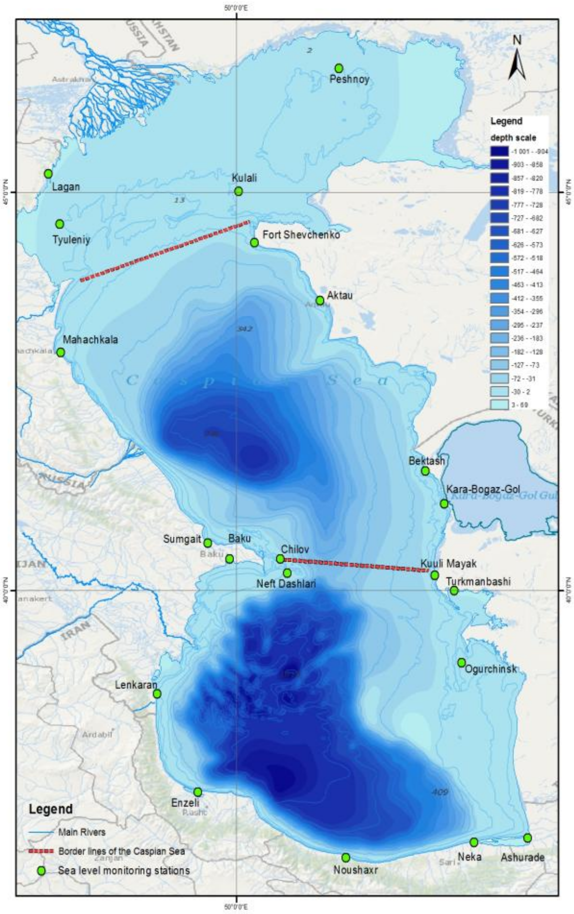

Fig. 1. The Caspian Sea topography and sea level monitoring stations

Results

The calculations are grouped in the North Caspian, Middle Caspian and South Caspian regions. It was determined that in-situ stations operating in the North Caspian region have sufficient correlation relationship. More precisely, from the southern part of the North Caspian region to northern part, correlation coefficient varry between 0.893-0.933. There are more in-situ stations in the Middle Caspian region compared to the Northern region. Based on comparative analysis of in-situ data during 1992-2011 the highest observed correlation relationships in this region varried from 0.806 to 0.974 (Makhachkala, Fort Shevchenko, Aktau, Makhachkala, Kulii Mayak, Kara-Bogaz-Gol and Chilov).

The South Caspian region is the second largest region after the Middle Caspian for the number of active in-situ stations. Processing of sea level data indicates that mainly a high coefficient of correlation (0.934 - 0.986) observed in Turkmenbashi, Neft Dashlari, Neka, Ogurchinsk and Kulii Mayak stations.

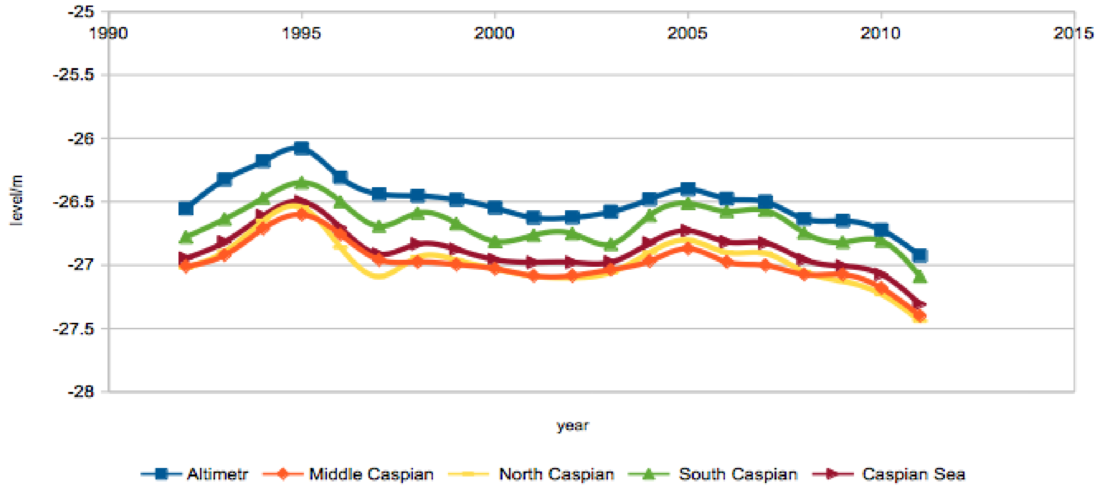

Fig. 2. Caspian Sea level variations by in situ and altimetry data

The correlation coefficients between stations in different regions of the sea were calculated in this research as well. So, it was determined that the most accurate sea level observations are achieved in Tyuleniy, Makhachkala, Neft Dashlari, Neka, Ogurcinsk, Kulii Mayak, Aktau and Pesnoy stations.

The average annual sea level data for the Caspian Sea and its three regions were comparatively analysed with the satellite data for the years 1992-2011 (Figure 2). As we can see from Figure 2, the average annual sea level data of the Caspian Sea is distributed in accordance with the general level change direction in three different regions. Overall, it was determined that the sea level was on rapid rise until 1995, and has been gradually falling since 1996. Although there were short-term level rise from 2003 to 2006, in general, the gradual decline process is still going on. Meanwhile, there was gradual decline in the Middle and South Caspian regions from 1996 to 2002 followed by sharp rise since 2003. As the figure shows, although satellite and ground-level data has relatively different numerical values, long-term distributions have the same characteristics. Given this, the correlation coefficients between the satellite data and lin-situ stations operating in the Caspian Sea have been calculated. For simplicity, correlation relationships between satellite and in-situ stations have been grouped in three regions of the Caspian Sea (Table 1).

Region of the sea	Observation stations	The period of the observations	Satellite and in situ station	Satelitte and average level
North Caspian	Tuleniy	1992-2011	0.8265	0,88
	Kulali	1992-2011	0.8792	
	Peshnoy	1992-2004	0.9614	
	Lagan	1998-2011	0.9302	
Middle Caspian	Mahachgala	1992-2011	0.9011	0,91
	Baku	1992-2011	0.8558	
	Chilov	1992-2011	0.6370	
	Kulii mayak	1992-2011	0.9487	
	Bekdash	1997-2008	0.4020	
	Aktau	1992-2011	0.8676	
	Sumgait	1998-2005	0.7152	
	Qara Bogaz Gol	1999-2011	0.8158	
	Fort Shevchenko	2000-2011	0.7758	
South Caspian	Lankaran	1992-2011	0.7724	0,87
	Anzali	1992-2011	0.5081	
	Ogurchinsk	1997-2011	0.8778	
	Ashurade	2007-2011	not enough data	
	Noushaxr	2001-2011	0.4057	
	Neka	1998-2011	0.8811	
	Neft Dashlari	1992-2011	0.8557	
	Turkmenbashi	1992-2011	0.9197	
Caspian Sea (total)	Total: 21	1992-2011	0.9	0,90

Table 1: Correlation between satellite altimetry data and in situ observation of the Caspian Sea

The table suggests that mainly high correlation was observed between satellite data and in-situ stations data. In addition, it was determined that the Middle Caspian region had a comparatively higher correlation relationship with satellite data**.**

Discussion

Although the sea level measurements of the Caspian Sea are carried out by 21 stations, sea level statements refer particularly to the observations of some of them. Correlation relations between all stations in the sea has been established in order to clarify the reasons of this case. In the early stages of this research sea level measuring stations with the highest correlation coefficients have been identified.

On the other hand, it was found that there is a high correlation relationship between the data from satellite altimeter and in-situ observation. We can concluded that the sea level analysis of the Caspian Sea via satellite altimetry data is very important and might be an efficient replacement for data from in-situ observations in the future.

Acknowledgements

This research was done as the part of the doctoral work registered at the National Academy of Sciences, Institute of Geography, the Division of the Caspian Sea Problems under the title "Study of level fluctuations of the Caspian Sea by satellite altimetry".

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The system of hydrometeorological observations on lakes and reservoirs of the Russian Federation

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Keywords: observing system, lakes and reservoirs, Russian Federation

Introduction

There are more than 2,200,000 lakes and reservoirs in the Russian Federation which are located in different landscape zones. Although routine hydrometeorological observations of certain lakes date back to the mid-19th century, a state observing network for lakes and reservoirs operating on the basis of common standards and regulations was established and intensively developed in the period from 1930 to 1986. In different years observations were made at more than 800 gauging stations and 1250 offshore sites for more than 430 lakes and reservoirs (currently only 347 stations and 324 sites on 169 lakes are under operation).

Description

Hydrometeorological observing system on lakes and reservoirs of Russia is one of the main parts of the state system for monitoring quantitative and qualitative characteristics of water regime. Therefore, most hydrometeorological sites on lakes and reservoirs include water quality observing stations.

The system is aimed at systematic observations and study of hydrometeorological regime of lakes and reservoirs to provide state authorities, sectors of economy and hydrological forecasting services with current information on hydrological regime and assessments of human and climate change impact on hydrological regime elements. Organization and design of the network, methods of observation and data processing are common throughout Russia and are governed by relevant regulations.

Most gauging stations perform observations of water level and temperature, air temperature, precipitation and the state of ice cover near the shore. Vertical profiling of water temperature at various depths, state of ice cover, currents etc. is made at points in offshore areas. All observations are made by the staff of territorial branches of Roshydromet (UGMSs) under methodological guidance provided by the State Hydrological Institute (SHI).

Hydrometerological observing system on lakes and reservoirs of the Russian Federation is subdivided into hydrometeorological observatories (HMO), hydrological stations and gauging stations. Hydrometeorological observatories and hydrological stations both organize observations and undertake research. Gauging stations are divided into first, second and third order stations depending on the type and amount of observations. Observation programme of a first order station providing for the biggest amount and types of observations is given in the table below.

Category of observations	Types of observations
Meteorological	Precipitation, atmospheric phenomena, ice cover, maximum and minimum air temperature.
Hydrological	Near-shore – water level, water temperature, ice phenomena, ice thickness, snow density on ice. Over lake area at a vertical – air temperature and humidity, wind direction and velocity, water temperature in a surface layer and in depth, water color and transparency.
Specialized observations and works	Waves and tides. Water sampling for chemical analyses.

Table 1. First order gauging station observation programme

Most observation sites (about 70%) are located on reservoirs. The largest reservoirs have 5 to 10 gauging stations. Computer processing of the observed data is made at hydrological stations using specialized computer technology developed at the State Hydrological Institute (SHI). The final output of the annual data processing is the hydrological annuals covering whole country. An electronic archive of long-term data since the beginning of observations has been established and is periodically updated. SHI manages a database containing the observation data and long-term series.

Future

In recent period a strategy has been adopted at national level for developing the system of hydrometeorological observations on lakes and reservoirs until 2020. This strategy provides for additional enhancement of lakes and reservoirs observing network, its technical modernization and automation through implementation of the Federal target programme "Development of Water Sector of the Russian Federation in 2012-2020". The amount of observation sites is projected to increase by more than 1,5 times up to 520-550 stations by 2020. The strategy also envisages development of observation network on reservoirs under construction in Siberia and the Far East of Russia (Boguchanskoye, Nizhne-Bureyskoye) as well as increase in the number of observation sites in the regions with a low density of stations.

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Robust remote sensing algorithms to derive ecological status for lakes

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Keywords: Water framework directive, lakes, chlorophyll a, phytoplankton biomass, Secchi depth, MERIS

Introduction

A fundamental work by official legislations is to assess and report on the environmental status and trend of water bodies (HELCOM 2007, EU Water Framework Directive (WFD) 2000/60/EC). WFD requires systematic monitoring of all inland waters larger than 0.5 km^2. Due to considerable temporal and spatial variability as well as inaccessibility and lack of resources, the status of water bodies is difficult to assess effectively by the existing monitoring programs. The need for new monitoring methods to meet the WFD reporting requirements has been highlighted (Dworak et al., 2005). Remote sensing methods allow better spatial and temporal estimation of some key factors - chlorophyll a content and transparency. Their changes are considered as primary indicators of eutrophication and climate change (Sommer & Winder, 2012).

The key objective of this study is to demonstrate how optically complex inland waters can be effectively monitored in the context of EU WFD by means of satellite derived products with a focus on chlorophyll a, total phytoplankton biomass and transparency.

Materials and methods

Description of lakes under study

The five studied lakes situate in North Europe (Figure 3). L.Vättern is deep and oligotrophic, L.Vänern is moderately nutrient-rich. L. Mälaren has a complex morphology and bathymetry with meso-eutrophic conditions. L. Peipsi and L. Võrtsjärv are large shallow lakes. While L. Võrtsjärv is homogeneously mixed and very turbid, L. Peipsi exhibits strong north-south gradient in water transparency, where its largest part L. Peipsi s.s. is the clearest and southernmost L. Pihkva very turbid. *In-situ* parameters were measured during national monitoring programs. Variation of yearly average values of Secchi transparency (SD) in each lake is in Figure 2. Their optical properties were presented in Alikas et al. (2010) and Paavel & Arst (2009).

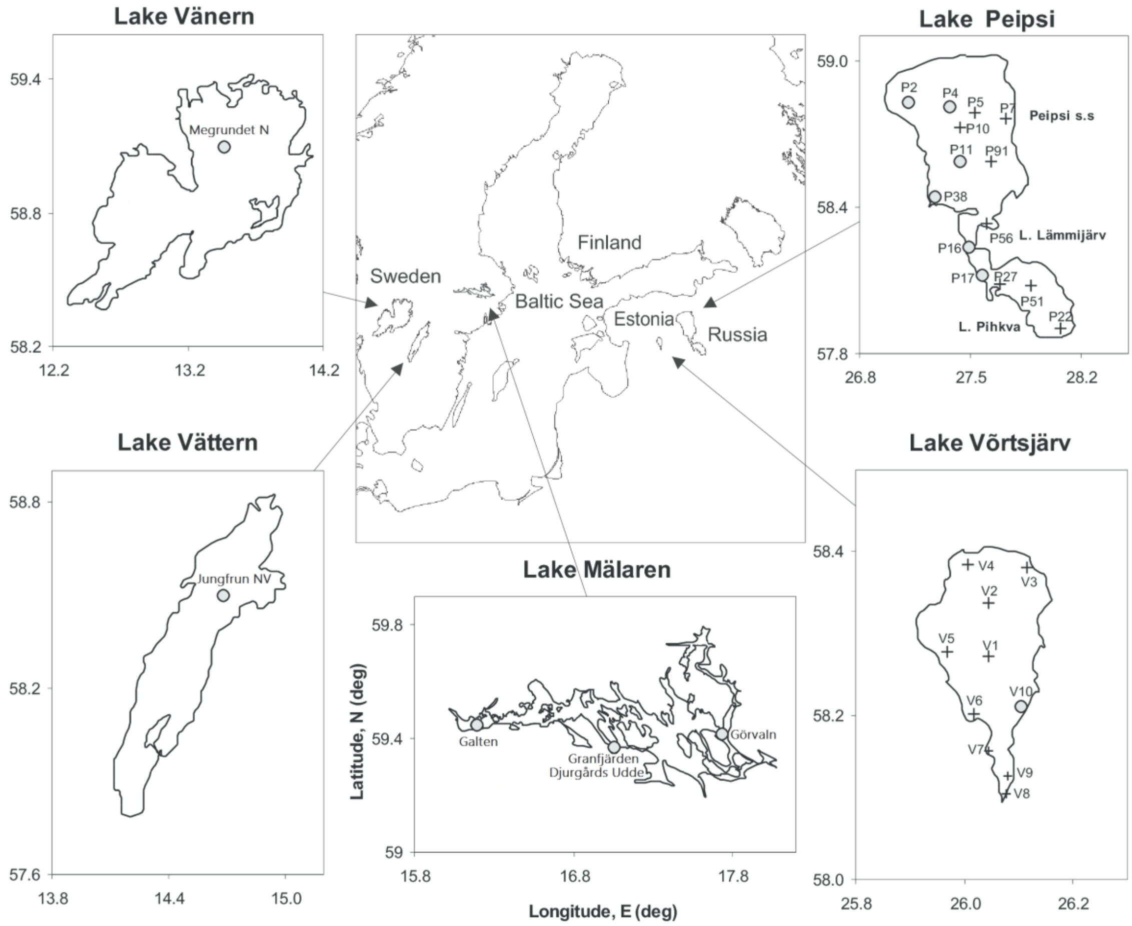

Figure 3. Studied lakes and the monitoring stations.

Satellite data processing

MERIS L1b (IPF 6.04) images (full resolution, 2002-2011) were processed with a Radiometry and ICOL processor to remove smile- and adjacency effects. From the corrected L1 products, the maximum chlorophyll index (MCI) was calculated following Gower et al. (2008), then Chl_a (Chl_a=10.9*MCI+15.3) and TBM (TBM=5.8*MCI+5.4) (Alikas et al., 2010) was calculated.

From the L2 reflectance and IOPs we used to estimate vertical diffuse and beam attenuation coefficients at 490 nm, K_d(490) and c(490). The relationship between the sum of these parameters over photosynthetically active radiation (PAR) and SD is found:

$$SD = \frac{8{,}35}{Kd(PAR) + c(PAR)}$$

where K_d(PAR)+c(PAR)=-0.0001x^2+0.7809x+0.4026, where x=K_d(490)+c(490), based on *in situ* measurements.

Regulations in Estonia and Sweden for ecological status assessment

The EU member states have freedom to build up their own monitoring system for fulfilling WFD requirements by choosing 1) the set of biological and physical-chemical parameters; 2) set class boundaries; 3) define monitoring period and 4) develop method for assigning final ecological status for a lake. Table 2 gives an overview of relevant monitoring period for Chl_a, TBM, SD for assigning the ecological status class.

Quality parameter	Unit	Timing	Lake	Ecological status class from WFD				
				High	Good	Moderate	Poor	Bad
Chl *a* concentration	mg m^3	Apr-Oct	Peipsi *s.s*	≤ 3	>3-8	>8-20	>20-38	>38
		Apr-Oct	Lämmi and Pihkva	≤6	>6-13	>13-37	>37-75	>75
		July-Aug	Võrtsjärv	≤24	>24–38	>38–45	>45–51	>51
		July-Aug	Clear lakes (Sweden)	≤5	>5-8.5	Additional phytoplankton data needed		
		July-Aug	Humic lakes (Sweden)	≤6	>6-10			
Phytoplankton biomass (TBM)	mg/L	Apr-Oct	Peipsi *s.s*	≤1	>1-2.6	>2.6-9.4	>9.4-17.3	>17.3
		Apr-Oct	Lämmi and Pihkva	≤2.6	>2.6-6.4	>6.4-16.1	>16.1-37	>37
			Võrtsjärv	-	-	-	-	-
		July-Aug	Clear lakes (Sweden)	≤0.6	>0.6-2.5	>2.5- 5	>5-10	>10
		July-Aug	Humic lakes (Sweden)					
Transparency (according to Secchi disc visibility)	m	Apr-Oct	Peipsi *s.s*	≤3.5	<3.5-2.5	<2.5-1.5	<1.5-1.0	<1.0
		Apr-Oct	Lämmi and Pihkva	≤2.0	<2.0-1.5	<1.5-1.0	<1.0-0.7	<0.7
		Apr-Oct	Võrtsjärv	≥0.9	<0.9-0.7	<0.7-0.6	<0.6-0.5	<0.5
	EQR	May-Oct	Clear lakes (Sweden)	≥0.67	≥0.5-<0.67	≥0.33-<0.5	≥0.25 - <0.33	<0.25
	EQR	May-Oct	Humic lakes (Sweden)					

Table 2. Borders for ecological status classes in studied lakes. L. Vättern, L. Vänern, Görväln Bay (L. Mälaren) represent clear-water lakes and the rest of L. Mälaren humic lakes (Bedömningsgrunder..., 2007**)**

Results

The combination of data from both resources (*in-situ* and satellite) improves the understanding of seasonal trends. The higher frequency of satellite data (*i.e.* for L. Peipsi 70 days of MERIS data vs. 7 days of *in-situ* data in 2006) increases the temporal continuity and detects small scale changes.

Conditions are relatively stable throughout the relevant monitoring period in clearer lakes (Vättern, Vänern -Table 1). Seasonal trends are more pronounced in turbid lakes and affecting the ecological status class assignment, especially if monitoring frequency is low. There was 100% agreement in resulting status class („Moderate“) between MERIS and *in-situ* data for L. Lämmijärv and for Peipsi s.s. in TBM and SD. With respect to Chl_*a* the agreement in L. Peipsi s.s is lower, which is explained by monitoring timing (phytoplankton bloom was missed by the regional monitoring in 2007 and in 2009 by MERIS due to cloud cover). The short monitoring period and relatively stable conditions inside the lake result in very narrow class boundaries (Table 1) for L. Võrtsjärv (0.4 m difference in SD from “High” status to “Bad”). This in turn results in highly varying status classes in L. Võrtsjärv. During 6 years higher status class from MERIS was assigned based on transparency and during 4 years based on Chl_a. For both methods, L. Võrtsjärv receives better status class based on SD compared to Chl_a. Lower SD and higher Chl_a were evident in 2003, 2006-2007 due to very low water level, which also resulted in lower ecological status classes.

Status class estimation for Görväln (L. Mälaren) ranges from “High” to “Moderate” with higher status class obtained according to in-situ values (57% of years according to transparency and 86% according to TBM). In more turbid Granfjärden and Galten, the status according to Chl_*a* was below “Good” according to *in-situ* and MERIS data, but as seen from Table 1, worse status classes cannot be determined without additional information about phytoplankton. In Granfjärden *in-situ* measurements gave better status class in 57% of years according to transparency and 71% according to TBM. Status class ranged from “Good” to “Poor” via in-situ and from “Good” to “Bad” via MERIS. L. Vänern and L. Vättern were in “High” status class by *in-situ* and by MERIS in all cases.

Lakes and their parts differentiate according to transparency retrieved from *in-situ* and MERIS data (Figure 2). The spatial differences were pronounced in L. Peipsi and in L. Mälaren, where northern parts of L. Peipsi belonging to “Moderate” and southern parts mainly to “Poor” or “Bad” status class and in L. Mälaren, Görväln “High” to “Moderate” and Galten Bay “Moderate” to “Poor”.

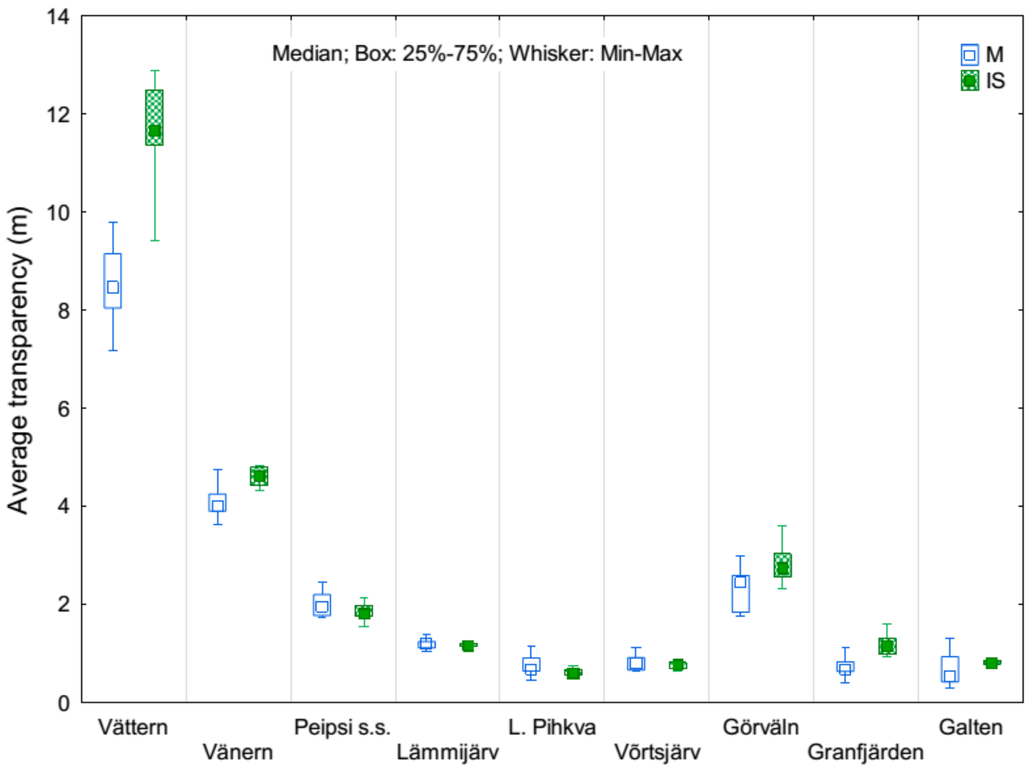

Fig. 4. Average transparency in lakes, measured with Secchi disc (IS) and retrieved from MERIS image (M)

Discussion

Relevant products for monitoring large lakes can be produced based on MERIS data. In general, *in-situ* and MERIS data showed similar seasonal and yearly trends for Chl_*a*, TBM and SD in all studied lakes.

Chl_*a* concentration is the most frequently investigated parameter regarding the possibilities to include remote sensing data into estimating parameters important for WFD applications (Bresciani et al., 2011). MERIS data revealed more detailed seasonal dynamics in Chl_*a*, TBM and SD compared to conventional monitoring methods. Although TBM and SD are not standard OC products, the algorithms were applicable to various lakes.

The discrepancies between the status estimate based on field and MERIS data can be explained by seasonality in combination with timing and monitoring frequency. As shown in this study and also by other authors (list in Bresciani et al., 2011), the timing of the data collection will influence the ecological status class assigned for a waterbody.

The ecological status class based on *in-situ* and MERIS data overlapped for L. Peipsi in almost all cases. Divergent status classification results were most frequently occurring in L.Võrtsjärv, ranging from „Good“ to „Bad“ during the 10-year period due to very narrow boundaries of parameters, and extreme water level fluctuations. Very narrow class borders demand sensitive remote sensing algorithms, but also very accurate field observation techniques and laboratory measurements. Therefore the frequently monitored time series of water quality parameters might give more valuable information about the lakes ecological status than sparse measurements.

The suggested methods to estimate Chl_*a*, TBM, SD are applicable to future MERIS-like sensors as the upcoming Sentinel-3/OLCI. Despite the differences in *in-situ* monitoring requirements and methods for assigning the ecological status class in different member states, remote sensing data could provide a unified picture of lakes and provide complementary long-term monitoring data.

Acknowledgements

We acknowledge the European Space Agency, the Centre for Limnology (Estonia), Swedish University of Agricultural Sciences, VeeOBS (3.2.0802.11-0043), ESF grant ETF8970 and FP7 GLaSS (313256) and WaterS (251527).

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Estimating inland water quality from WorldView-2 imagery: decoupling optical properties

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Keywords: matrix inversion; variable SIOP; bio-optical properties; band ratios; seasonal variation

Introduction

Semi-analytical inversion algorithms based on the matrix inversion methods (MIM, Hoge and Lyon 1996) use in situ bio-optical measurements of absorption and backscattering to model satellite reflectance which are then used to linearly resolve for water constituents concentrations including phytoplankton absorption, the combined coloured dissolved organic matter (CDOM) and non algal particulate (NAP) absorption (Brando and Dekker 2003). An adaptation on this method by Hoogenboom et al. (1998) called a linear matrix inversion (LMI) enabled the retrieval from optically complex waters, of all the optically active concentrations independently. Brando et al. (2012) extended the model to utilise and adapt to a range of naturally occurring inherent optical property (IOP) spectral shapes including absorption and backscattering coefficients. This adaptation (named *a-LMI*) allows the model to vary the water constituents independently, effectively decoupling them, and then to retrieve water quality concentrations that better represent the natural spatial variability.

The objective of this study was to test the *a-LMI* inversion algorithm and evaluate the accuracy and usefulness of its application to eutrophic inland waters, specifically, to determine if the *a-LMI* has the ability to decouple chlorophyll-a from other optically active constituents in highly turbid, eutrophic conditions.

Materials and methods

Lake Burley Griffin was formed in 1963 and runs through the centre of Canberra (South-east Australia). The prevailing seasonal weather conditions significantly influence the Lake's physical and chemical characteristics (Lawrence, 2012). A limited set of bio-optical data was collected from a range of sites within Lake Burley Griffin and were used to parameterize the *a-LMI* model as described in (Brando et al. 2012).

Site	Date	Chl *a* ($\mu g\ L^{-1}$)	NAP ($mg\ L^{-1}$)	a_{CDOM}(*440nm*) (m^{-1})	b_{bp}(*555nm*) (m^{-1})
LBG1	7 January 2010	7.2 - 23.5	1.7 - 9.6	0.47 - 0.68	0.035 - 0.119
LBG2	28 January 2010	23.8 - 64.1	2.7 - 8.3	0.45 - 0.65	0.076 - 0.155
LBG3	4 March 2010	71.6 - 126.3	3.8 - 13.5	1.23 - 3.03	0.067 - 0.095

Table 3. The in situ data available for the *a-LMI* parameterisation for Lake Burley Griffin in 2010

Table 1 illustrates the variability that was sampled within the lake; these widely varying sets of measured IOPs and specific inherent optical properties (SIOPs) were used to create SIOP shape and amplitude factors for each of the water constituents (specific absorption coefficients of chlorophyll-a, NAP, specific backscattering coefficients of chlorophyll-a and NAP, the spectral slope constants for CDOM and NAP and the power lay exponents for NAP and chlorophyll-a) (Brando et al. 2012). Each of these model parameter sets allows *a-LMI* to represent all the combinations of the water constituents and constrains the model from producing unnatural combinations of water constituents.
The inversions of IOPs are based on the relationship between remote sensing reflectance and the absorption and backscattering coefficients (Gordon et al. 1988). The subsurface remote sensing reflectance (r_{rs}) is computed for optically deep water through a radiative transfer equation correcting the above water remote sensing reflectance R_{rs} for the air-surface interface (Lee, Carder and Arnone 2002) at a nadir view angle each wavelength (λ).

$$\boldsymbol{r_{rs}(\lambda) \approx \frac{R_{rs}(\lambda)}{0.52+1.7R_{rs}(\lambda)}}$$

Water quality information (e.g. IOPs and concentrations) are found by inverting the remotely sensed signal, given the relationship between the r_{rs} and the inherent optical properties (IOPs) absorption (a) and backscattering (b_b), as is given in Gordon et al. 1988.

$$\boldsymbol{r_{rs}(\lambda) = g_0\left(\frac{b_b(\lambda)}{a(\lambda)+b_b(\lambda)}\right) + g_1\left(\frac{b_b(\lambda)}{a(\lambda)+b_b(\lambda)}\right)^2}$$

Where g_0 and g_1 are the geometric factors or model constants that vary with the sun and sensor geometry.
High resolution, 8-band multispectral WorldView-2 (WV2) satellite imagery of the lake were acquired in summer, early autumn and winter 2010 and were free of most obvious atmospheric effects.
The atmospheric correction c-WOMBAT-c (Brando and Dekker, 2003) was applied to the WorldView-2 data. As there were no coincident radiometric observations with the satellite

imagery, the atmospheric correction was evaluated using pseudo invariant features (PIFs) around the foreshore of the lake.

Results

As limited concurrent *in situ* observations existed, the EcoLight 5.2 IOP model (Mobley 2013) was used to simulate r_{rs} using *in situ* absorption and beam attenuation measurements. The *a-LMI* model retrievals from the simulated spectra had good agreement between the modeled and measured results for chlorophyll-a concentration and CDOM absorption at 440nm but generally underestimated NAP when conditions were highly eutrophic.

The *a-LMI* model was then applied to the WV2 images (Fig. 5). The *a-LMI* chlorophyll-a retrievals were realistic but relatively high for the January image (Fig. 5, top), bloom conditions for the March (Fig. 5, middle) and lower winter concentrations in July (Fig. 5, bottom). The *a-LMI* model was unable to retrieve results in the eastern section of the lake in January and July and in the western section in July.

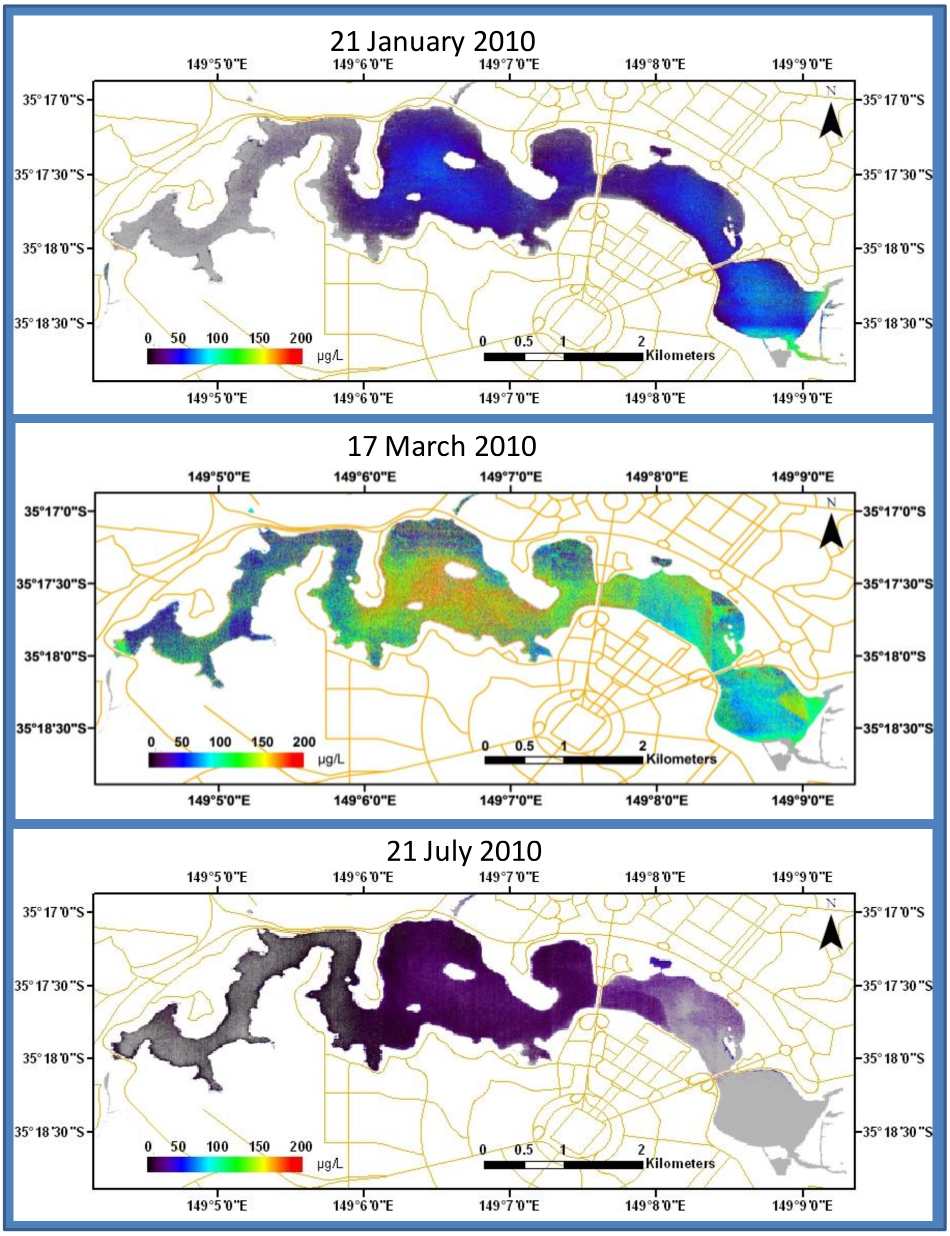

Fig. 5. *a-LMI* results for the three WorldView2 images showing chlorophyll-a concentration variation over the 6 month period from January to July 2012. The grey areas are where the *a-LMI* did not retrieve a result.

Discussion

The study site exhibited high to extreme variability during the study period. The *a-LMI* method, with its variable SIOP model that decouples the optical properties of the water constituents, have compared satisfactorily with data from an independent water quality sampling program when applied to the WV2 imagery to retrieve seasonal variations in the derived water quality products (Fig. 6).

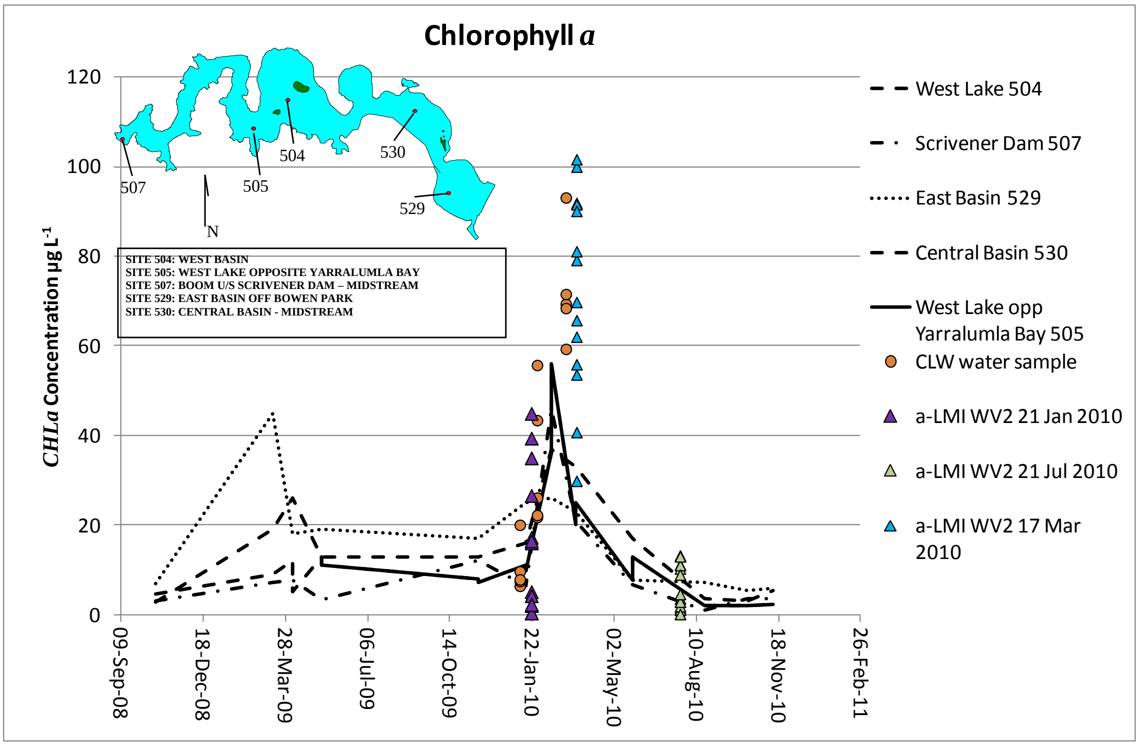

Fig. 6. Comparison of the *a-LMI* result with the temporal range of in situ measurements: the lines describe the measured chlorophyll-a concentration from regular water quality monitoring at five sites in the lake. Circles represent the chlorophyll concentrations taken from the targeted fieldwork for this study and triangles are the *a-LMI* retrievals derived from sites within the WV2 images**.**

The *a-LMI* model applied quality assessment flags based upon spectral matching of the satellite measured spectrum to the optimal calculated spectrum using the available bio-optical variability. The disparity between the best modelled spectrum and the satellite spectrum indicated where the input SIOP variability was not representative of the variability actually occurring in the satellite image. Thus the *a-LMI* method has an inherent property to discount spurious results and pinpoint where improvements in bio-optical parameterisation are required - enhancing confidence in the end product.

Previous research has indicated that the variability of the bio-optical properties of the lake were too complex for band ratio algorithms. This study confirms that the variability of the bio-optical properties of the lake were shown to be too large for a single fixed SIOP model parameterisation as is implicit in many other semi-analytical inversion or empirical inversion methods. The *a-LMI* model worked satisfactorily when applied to this turbid eutrophic inland lake and its application to other inland waters has potential. Successful application of the *a-LMI* method with its variable SIOP model, would be dependent on the representativeness of the parameterisation of the SIOPs.

Acknowledgements

Financial support was provided by CSIRO Land and Water: Capability Development Fund Projects and the CSIRO Flagship: Water from a Healthy Country. The imagery was provided under license by Sinclair Knight and Mertz and DigitalGlobe, the field monitoring data was provided by the National Capital Authority. Thanks to Paul Daniel, Rebecca Edwards and Nora Egli who assisted in the field campaigns.

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A critical review on monitoring of lake water quality and ecosystem information using satellite images: towards a new era of water color remote sensing

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Keywords: satellite remote sensing, lake water quality, algal bloom, macrophytes, monitoring

Introduction

Many methods have been proposed to retrieve the parameters related to lake water quality and/or ecosystem information from satellite images. Water quality includes chlorophyll *a* (Chla), suspended solids (SS), colored dissolve organic matter (CDOM), water clarity, diffuse attenuation coefficient (Kd), inherent optical properties (IOPs) etc. and ecosystem information contains primary productivity, distributions of macrophytes, algal blooms, etc. First, general problems in water color remote sensing are pointed out and summarized. Second, we have tried to classify previously proposed methods from the view of retrieving items, monitoring purpose, information of target lakes, sensor/satellite information, atmospheric correction, etc. Third, future research directions to utilize satellite images for appropriate lake management are discussed as a start towards a new era of water color remote sensing. Finally, in the context of a new era, conceptual sequential judgement system is proposed to capture the water and/or vegetation characteristics in the lakes as to which little information has been obtained.

General problems in water color remote sensing

Three inherent problems in water color remote sensing are mentioned and identified for lake research. They are (1) atmospheric correction, (2) mixtures of several components, and (3) disturbances on water surface and bottoms.

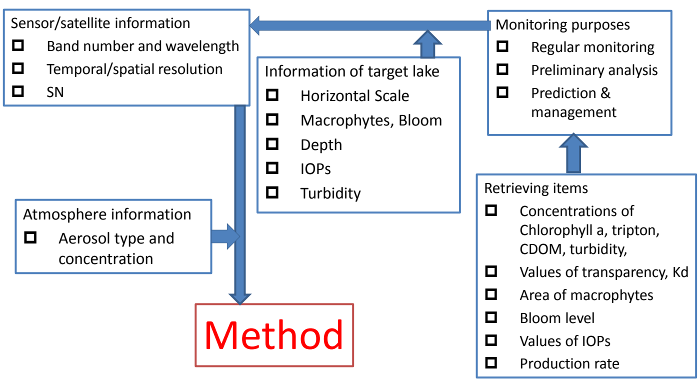

Fig. 1 Pre/post information to select the analytical methods

Classification of previous methods

Selection of retrieving method depends on the information of targeted lake. A set of information is listed in Fig. 1. Several our studies (Oyama et al. 2009; Yang et al., 2011a; Yang et al., 2011b; Matsushita et al., 2012; Jaelani et al., 2013; Oyama et al., in press) and relevant previous studies are exemplified and then classification of many methods proposed in these papers is tried from the view of pre/post information of the target lake (bathymetry, presence or absence of macrophytes, color of bottoms, etc.).

Future research directions

Based on the discussion on the previous sections, future research directions are proposed as shown in Table 1.

- Data-bank (database) of SIOPs
- Most turbid lakes (L. Tonle sap): atmospheric correction and water quality estimation
- Classification of different regimes (or Hybrid model: switch between different algorithms): clear, turbid, most turbid,,,
- Classification of phytoplankton/macrophytes at class level or categories based on their habitat of growth
- 2D Mixel of cyanobacterial bloom and macrophytes
- Optical depth (deep: only water, shallow: sediments)
- High spatial and temporal resolution: data fusion
- Blending images of different sensors
- Correspondence to vertical water quality profile
- Combination with hydrodynamic/ecological modelling

Table 1 Future study for lakes

Conceptual sequential judgment system

As one example of future research target, a system of conceptual sequential judgement is proposed for the water body regarding on which water and/or vegetation information is seldom available. Many indices are proposed to judge what kind of pixel is it (Fig. 2).

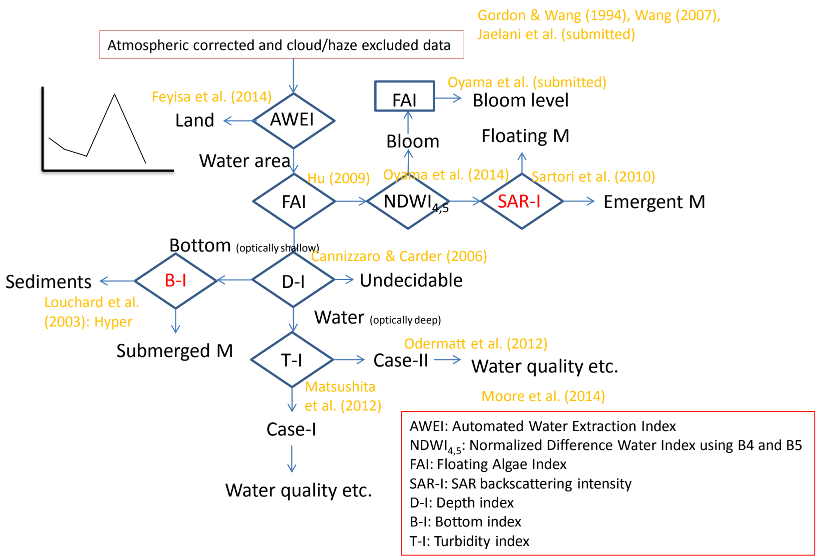

Fig. 2 Constructing conceptual sequential judgement

Acknowledgements

This study is partly supported by the Grants-in-Aid for Scientific Research of MEXT, JAPAN (23404015, 24110006, 25420555, and 26281039) and Environmental Research and Technology Development Fund (B-0909 and S-9-4-(1)).

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Detection and monitoring capabilities of future satellite sensors for lakes and reservoirs

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Keywords: remote sensing, hyperspectral, primary productivity, chlorophyll, phycocyanin

Introduction

Freshwater is a fundamental resource for human life, and the services provided by surface freshwater ecosystems underpin global water and food security and economic productivity. To improve understanding of global freshwater responses to multiple stressors, standardized, accurate data are needed. Timely, spatially explicit information from optical remote sensing can provide important input into managing and mitigating negative effects of human land management and climate change and variability.

High spectral resolution (hyperspectral) remote sensing, or imaging spectroscopy, provides measurements across 100s of discrete bands, forming a contiguous spectrum that enables detection and identification of earth surface materials, which provides quantitative measurements of ecosystem properties and processes incomparable to other remote sensing modalities. Archival, global mapping satellite missions provide systematic measurements over years to decades, providing a time series of consistently measured data to assess system condition, identify change, and understand process for a limited, but important suite of biophysical variables. The following case studies illustrate how the characteristics of a hyperspectral global mapping satellite mission, such as the planned Hyspiri mission, address the needs of freshwater aquatic system scientists and managers. We use as our example for freshwater aquatic ecology the remote sensing of primary producers. In the following case studies we highlight published data and existing methods, demonstrating the maturity of the science. However, each case study demonstrates existing gaps in the spatial, temporal, and spectral characteristics of the application, highlighting the need of a mission that will fill these gaps.

Materials and methods

The Mantua lake system is an important freshwater wetland system in Northern Italy that provides critical habitat for hydro-hygrophilous vegetation and water birds in the region. The Mantua system is formed by the damming of the Mincio River, a tributary of the Po, and fed by Lake Garda, the largest lake and longest river of Italy, respectively. The lake waters are extremely productive, characterized by eutrophic to dystrophic levels. Recent studies (e.g., (Bolpagni et al. 2014; Bresciani et al. 2009; Bresciani et al. 2013; Villa et al. 2014a; Villa et al. 2014b) have shown the capability of three sensors mounted on ground, airborne and satellite platforms, in observing optical properties of different primary producers of these lakes.

Results

Figure 1 shows the phycocyanin (PC) index in Upper Mantua Lake, calculated from an above-water *in situ* high temporal frequency, high spectral resolution radiometer using Kutser et al.'s (2006) algorithm. The measurements are plotted in grey dots, the measurement made at 10:30 am is plotted in red, and the black line indicates the spline-smoothed daily median trend. The grey vertical bars indicate the overpass dates of Landsat 7.

We estimated the CHL concentration in Mantua lakes using airborne data gathered from APEX (Airborne Prism EXperiment). The image was acquired on the Upper Lake on 21 September 2011, with a ground resolution of four meters. The APEX data were converted into CHL concentration according conversion factors specific for Mantua lakes (Bresciani et al. 2013). The APEX-derived map was then convolved to the spatial resolution of Landsat, Hyspiri, MERIS and MODIS using nearest-neighbor re-sampling.

Discussion

Figure 1 shows the daytime and day-to-day dynamics of cyanobacteria in Lake Mantua from high spectral resolution radiometric measurements. High spectral resolution is necessary for detecting PC spectral features. Of the current spaceborne multispectral sensors, only MERIS has the spectral bands in the positions required to detect PC (Kutser 2009), and even then it lacks the high spectral resolution to detect PC when it is present in large quantities. The temporal frequency of a global mapping mission with a revisit time similar to Landsat is likely not adequate to cover the temporal dynamics evident in this example (Figure 1). High temporal resolution imaging spectroradiometry from geostationary satellite platforms could synoptically capture the temporal dynamics of cyanobacterial blooms. However, spatial resolution limits the practical application of such platforms for systems such as the Mantua lakes.

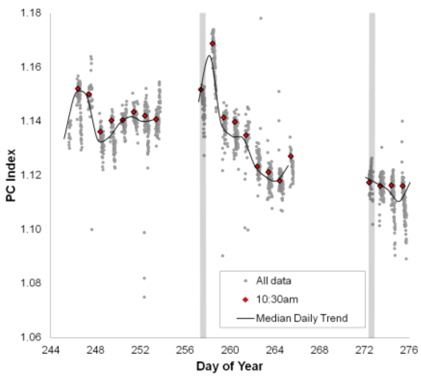

Fig. 1. Phycoyanin index measured from high spectral resolution above water radiometry

Figure 2 shows the map of CHL concentration derived from the APEX image. Clearly the maps show how the spatial resize affects the ability to measure the patchy spatial distribution of CHL captured in the 4 m pixel of APEX; the 30 m and the 60 m resolution of Landsat and Hyspiri still allow the spatial trends of CHL concentration to be captured, although finer scale patterns vanish. Neither MERIS nor MODIS have the appropriate spatial resolution to assess CHL in the Mantua lakes.

Archival, global mapping missions with multispectral (e.g., Landsat) or narrow band moderate spectral resolution sensors (e.g., MERIS) have provided high quality data from which many ecosystem process studies of the terrestrial and coastal zone have been achieved. However, these sensors have measurement resolution tradeoffs that make them unsuited for freshwater ecosystem studies. For example, while Landsat has the spatial resolution for freshwater systems, it cannot provide the spectral resolution to resolve phytoplankton pigments. Similarly, MERIS spectral bands are well suited for water column characterization and high frequency measurements, but the pixel size limits the number of freshwater systems resolvable from that sensor.

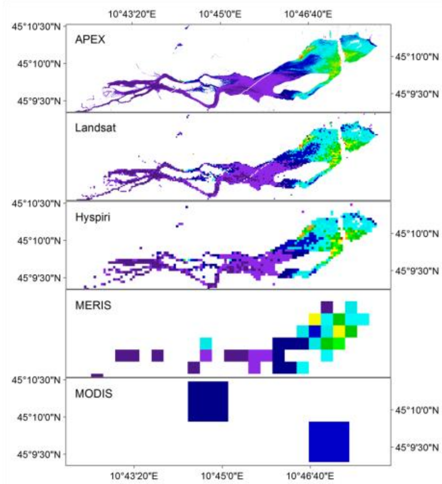

Fig. 2. CHL concentration in Upper Mantua Lake from the APEX airborne imaging spectrometer (top), and re-sampled to different sensor spatial resolutions. Color scale ranges from purple to red for CHL ranging from 0 to 60 mgm^{-3}

Unlike multispectral terrestrial and ocean color missions that have band positions selected for targeted applications that necessarily limit the biophysical variables retrieved from a given sensor, a hyperspectral mission (with necessarily high fidelity) provides the spectral information needed to retrieve multiple biophysical variables simultaneously from both the water column and wetland/riparian components of freshwater ecosystems. The result of this capability is that by using just one measurement, it is possible to gain improved understanding of ecosystem properties and processes, using converging lines of from different parts of the spectrum. In our case studies, we presented the estimation of only a single biophysical variable at a time. While current algorithms tend to be targeted to retrieve just one or a few biophysical variables at a time, algorithm developments supported by comprehensive high quality hyperspectral datasets (e.g. HICO) may lead to algorithms that perform multiple variable retrievals from a single processing chain. A hyperspectral global mapping mission will provide the data needed to investigate robust algorithm development, including a global atmospheric correction solution and new biophysical variable retrievals, such as phytoplankton functional types (Devred et al. 2013).

Acknowledgements
We thank R. Colombo and his group (University of Milano Bicocca) for the experiment with the multiplexer radiometer irradiometer (MRI) in Mantua lakes. APEX data were acquired thanks to the European Facility for Airborne Research (EUFAR) project. E. Hestir was supported by CSIRO Division of Land and Water. A. Dekker was supported by the CSIRO Earth Observation Informatics Transformation Capability Platform. This study was co-funded by Italian Space Agency (CLAM-PHYM project, contract n. I/015/11/0), European Union (FP7-People Co-funding of Regional, National and International Programmes, GA n. 600407 and FP7-Space INFORM GA n. 606865) and the CNR RITMARE Flagship Project.

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Application of GIS and Remote Sensing techniques to analyze lake water balance in a sparsely gauged catchment: case study Burabay National Nature Park, Kazakhstan

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Keywords: lake management, Geographic information systems, remote sensing, hydrology

Introduction

The Burabay National Park (BNP) is located in the North of Kazakhstan within the watershed of the Esil river basin, which in turn is the part of a big Ob river basin. The whole lake system is bounded within 52°59¢ - 53°07¢N and 70°13¢ - 70°17¢E and at an average altitude of around 341 meter above sea level. The area is characterized by strong continental climate with an average annual rainfall of 317 mm and evaporation rates of 600-700 mm. Remote sensing techniques have been widely used to study components of hydrological cycle in different geographical locations. Geographic Information Systems and remote sensing play an important role in effective management of water resources and provide an opportunity to create and analyze data related to lake management issues.

The term “lake management” means management designed to maintain an ongoing viability of lake ecosystems that provide the basis for aquatic and non-aquatic life. In order to aim such goals, it is important to know the present ecological conditions of lakes and their biological, chemical and physical characteristics. With the use of GIS and Remote Sensing, water systems data can be analyzed and alternative management scenarios can be presented. The final outcome will help decision makers such as park authorities and governmental institutions to effectively monitor the lakes conditions, implement recovery strategies, and address any other water issues in Burabay park area.

Burabay National Nature Park was established in August 2000 and is under the supervision of the Executive Office of the President. The topography of this area has lowlands, plains, forests and hills. Burabay National Park has 14 lakes with an area of more than 1 km each and many other small lakes. For our research, we mainly observe four of them: lakes Shortan, Borovoe, Ulken Shabakty and Kishi Shabakty. There is no ongoing complex research regarding the hydrological cycles of the Burabay lakes. The area is poorly gauged with any types of equipment for studying the catchment, for example, the absence of rain gauges. There is no comprehensive work that has been done to study lake systems in strongly continental climates with mean annual temperature difference of around 60 ^{o}C using GIS and Remote Sensing. This study intends to assimilate data using Remote Sensing techniques and utilize GIS as a platform for building Decision Support System for sustainable lake management under continental climate conditions.

Materials and methods

Remote sensing and GIS have a wide range of applications in different fields. Hydrological analysis of the water bodies will be more efficient with the use of these tools. For example, authors Usali and Ismail discuss in their research the applications of GIS and remote sensing in monitoring water quality parameters such as turbidity, dissolved organic matter, suspended matter and phytoplankton (2010). Remote sensing in hydrology gives an opportunity for obtaining and interpreting the data and mainly acts as an information source (Baban, 1999). GIS techniques are used to combine different data, analyze them, create new data, compare and evaluate results.

The similar to our research project was held in Lake Koronia, Greece. Alexandriris and other researchers used remote sensing and GIS for planning and restoration of the Lake Koronia (2007). Remotely sensed data and on-ground field data were assessed to determine the level of degradation of Lake Koronia (Alexandridis et al., 2007). Watershed assessment in this research project was used to consider the main driving factors of the degradation in the watershed area.

In our studies, the first step towards the use of GIS and remote sensing in Burabay lakes management was to assess the watershed of the lakes as well. At this step, data acquisition plays an important role. The satellite images Landsat7/ETM+ with 15m spatial resolution, topographical maps and digital elevation model Aster GDEM v.2 of the area were used in order to get watershed delineation of the lakes. All procedures were performed on WGS 84 geographic coordinate system. The watershed delineation process was performed on ArcGIS 10.1 using Hydrology tools of the Spatial Analyst function:

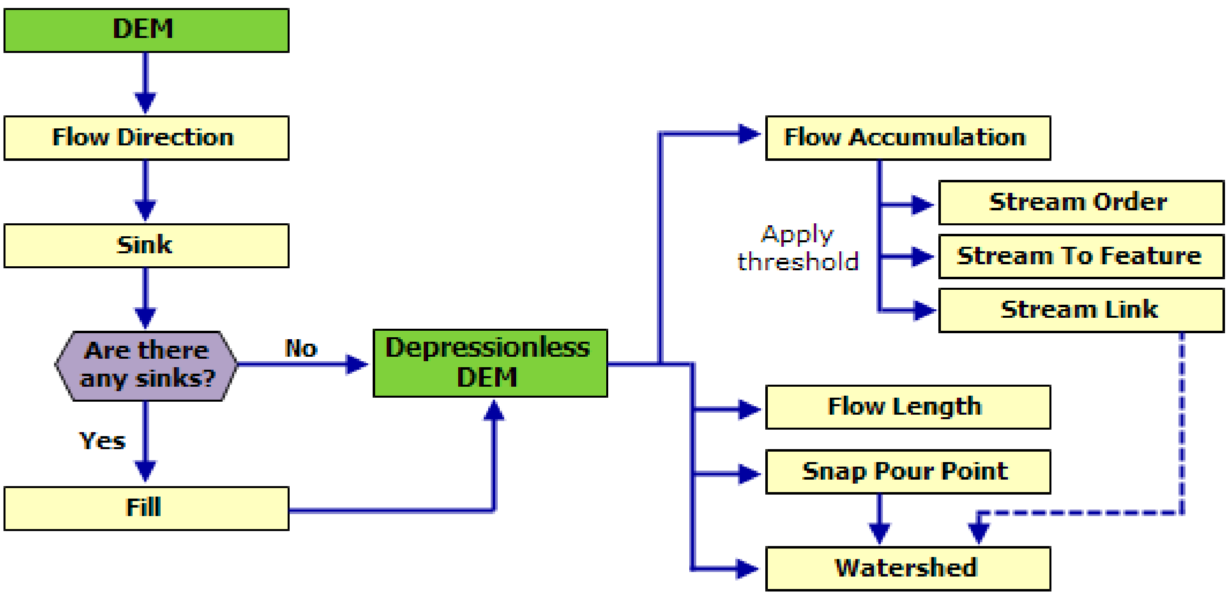

Fig. 1. Watershed delineation procedures

Watershed assessment of the area can be derived creating the watershed on ArcGIS 10.1 using the above stated scheme.

Results

Layers such as flow direction, flow accumulation, flow length and other steps towards watershed delineation were produced on ArcMap using the hydrology tools of the Spatial Analyst function. The final outcome of the Burabay watershed area looks like this:

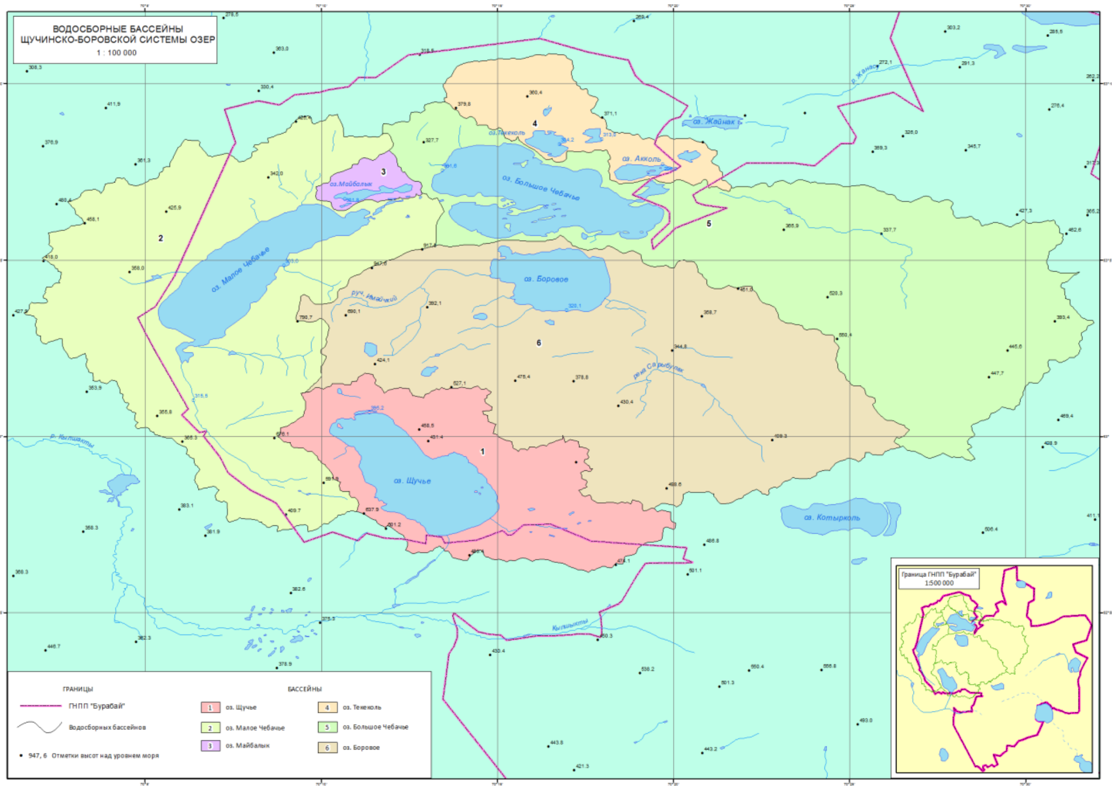

Fig. 2. Final outcome: watershed delineation of the Burabay lakes.

The data on watershed delineation of Burabay lakes is the fundamental step in the analysis of hydrological cycle of the lakes. This data gives us the overall map of the watersheds and lakes ecosystem and provides an opportunity for a future use of GIS tools in our research.
Digital elevation model will be used for further surface hydrological analysis and bathymetric data can be created in order to study the bottom of the lakes. The purpose of this study was to demonstrate the effective use of GIS in delineating watersheds of the Burabay lakes. The advantage of remote sensing is its ability to capture and record land surface details. Its spatial resolution and aerial coverage provide the researcher with a broad view of a land surface. Remotely sensed data can be stored and analyzed effectively in a GIS.

Discussion

Data acquisition is one of the important and time consuming steps in GIS and remote sensing. Unfortunately, restricted availability of the data on Burabay park lakes consumed time which could be efficiently used if the data was easily available. The issue was even more complicated due to a lack of cooperation between different entities who are interested in research in this area and unwillingness to share data with others.

For future research goals, it is recommended to combine GIS and remote sensing data with on-ground field work for a higher quality data that we can further use. The watershed delineation of Burabay lakes, such as Shortan, Burabay, Kishi Shabakty and Ulken Shabakty will help to build the whole image of the Burabay lakes basin (watersheds) and will strengthen the effective lake management and conservation strategies through the hydrological assessment of area.

In our study, remote sensing can be further used in snow hydrology. Snowmelt runoff modelling is applied to evaluate hydrological effects of the climate change. Remote sensing by satellite images can demonstrate the dynamic changes of snow coverage over the area (Seidel and Martinec, 2004). Since Burabay National Nature Park is located under the continental climate in the north of Kazakhstan, the snow cover of the region can be a good indicator of the effects of climate change on lakes systems. Another future application of GIS and remote sensing in the research can contribute to sustainable water resource management by monitoring water quality parameters. So, both GIS and remote sensing combined with field trip data can be efficiently used for lake management issues. GIS and remote sensing provide solutions in water resources planning and management. Alexandridis et al. in their research pointed out that new possibility like GIS is employed to reduce costs such as time and money during the research (2007).

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Monitoring the spatio-temporal dynamics of water quality in Lake Malawi from space

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Keywords: Remote sensing, water quality

Introduction

Lake Malawi is the southernmost and third largest of the East African great Lakes. The lake provides Malawi with vital ecosystem services including fresh water, food and livelihoods. It is important for local transportation, and through its outflow into the Shire River, it provides the country with its main source of hydroelectric power. In addition, it is an important tourist destination. The lake and its tributaries provide an estimated 70% of the animal protein consumed in the country. Lake Malawi is oligotrophic, the production of phytoplankton is limited mostly by the loss of nutrients to an almost permanent stratified, anoxic water layer at a depth below 250m (Eccles 1962). The Lake Malawi Ecosystem Management Project (2002), that studied the water quality of the major contributing rivers, concluded that several rivers are substantially altered by human activities within their catchment, and that these rivers especially in the southern part of the Lake were already changing the water quality and algal communities in local and larger areas of the lake. The nutrient and sediment loading to the lake from its tributaries was estimated to have increased by 50% within the last century (Hecky et al. 1999). However, little systematic information exists on the spatio-temporal and long-term dynamics of water quality in this lake. In a project within the eoworld program, the use of remote sensing for monitoring the ecological status of the lake was assessed. In the following, in particular the results for chlorophyll-a will be presented and discussed.

Materials and methods

Several water quality parameters were derived from Envisat-MERIS full resolution images and water temperature from Envisat-AATSR images for the years 2010 and 2011. MERIS images were preprocessed with the C2R atmospheric correction algorithm (Doerffer and Schiller 2007) and processed with the WISP algorithm (Peters in prep) into the water quality parameters chlorophyll-a, total suspended matter, coloured dissolved organic matter and k_d (vertical diffuse attenuation coefficient). The images were analysed individually and also aggregated into monthly mean values and mean values over the entire lake and different parts of the lake, respectively. To explain the observed patterns, records of the Malawi Meteorological Services were retrieved and compared to observed anomalies in water quality.

Results

Overall, the chlorophyll-a concentrations were found to be very low (around 0.5 mg/m^3) and not very variable. A time series of monthly averages over the whole lake is given in Figure 1. Spatially, concentrations are higher in the southern part of the lake, in particular along the south-western shore, and in the very north.

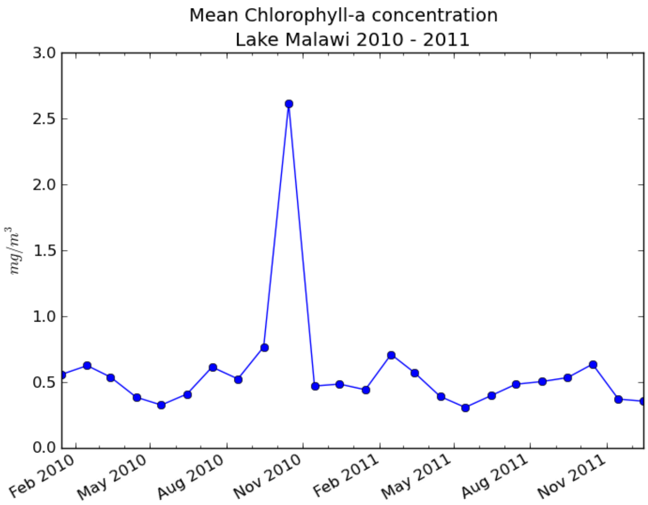

Fig. 1. Mean monthly chlorophyll-a concentration averaged over Lake Malawi

Temporally, in the months of October and February, elevated concentrations were observed, with an atypical high peak in October 2010 in the Northern part of the lake (see Figure 1 and Figure 2). The mean concentration of the whole lake reached values around 2.7mg/m^3, but a large area of the lake showed concentrations around 20-30 mg/m^3.

For validation, no actual match-up in-situ measurements were available. Therefore, a comparison with the few published records of chlorophyll concentration was performed. Guilford et al (1999) sampled several stations close to the south-western shore during three seasons and found mean Chl-a concentrations between 0.5 and 1.5mg/m^3. The World Lake Database contains one data set of Chl-a concentration for one station containing monthly average values. At a depth of 10m, these values range from 0.2 to 1.3mg/m^3. Based on these historical data we can conclude that the Chlorophyll-a values derived from satellite data are very well in accordance with known ranges.

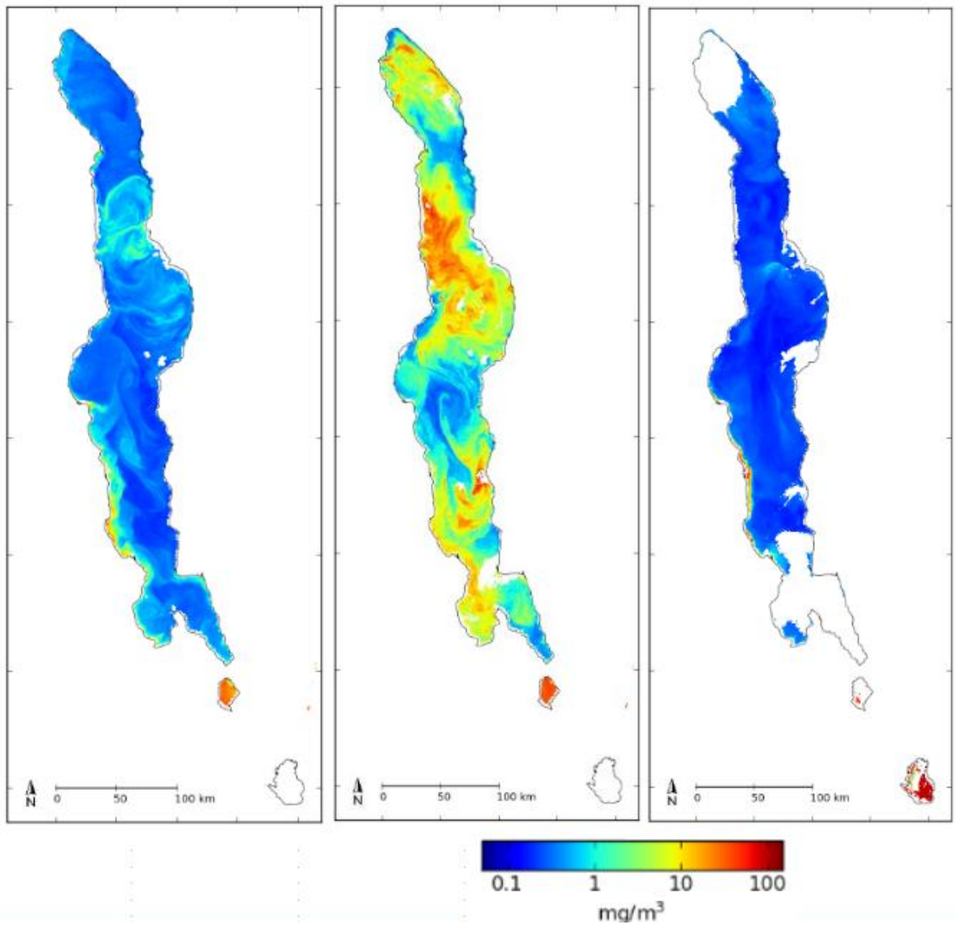

Fig. 2. Chlorophyll-a concentration in Lake Malawi derived from MERIS images on 20/09/2010 (left), 03/10/2010 (middle) and 15/10/2010 (right)

Discussion

The observed spatial and temporal patterns of Chl-a for the most part conform to expectations: Spatially, the higher-than-average values along the south-western shore can be explained by the higher population density in the river catchments in this area, leading to higher erosion rates and higher sewage discharge. The nutrients transported into the lake lead to higher primary production that is reflected in the Chl-a concentrations. Temporally, the slightly elevated concentrations values in October and February can be related to the start and peak of the rainy season, leading to increased erosion, and subsequently nutrient inflow into the lake.

Several hypotheses explaining what caused the very high peak in October 2010 were investigated using ancillary information including surface temperature data and weather records. The first hypothesis that the peak was caused by high amounts of riverine inputs at the onset of the rainy season was rendered unlikely because rains did not commence until late October 2010. A second hypothesis that this peak was caused by severe storms causing sudden deep mixing was also not supported by weather records, because there is no evidence for high wind speeds during October 2010. The third hypothesis is that vertical turbulent mixing caused nutrient-rich water from deeper layers to be propelled upwards, leading to an algal bloom. The reason for this mixing could be a sudden stop of the lake circulation driven by trade winds, leading to an unstable situation in the hydraulic flow within the lake. The hydraulic energy could be transformed to vertical turbulent mixing (maybe also caused by a dampening of seiches) and, during a short period, water from deeper layers could be propelled upwards. So far, the third hypothesis seems the most likely. Further investigation is necessary to understand the causes and effects of such algal blooms.

Acknowledgements

This work was supported by ESA and World Bank under the eoworld programme, project "Zambezi river basin mapping".

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Using High Performance Computing to enable interactive design of measures to improve water quality and ecological state of Lake Marken

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Keywords: ecological state, water quality, shallow lake, interactive design, high performance computing

Introduction

For several Dutch shallow lakes, high suspended sediment concentrations result in reduced ecological values and prevent goals and standards from being met (Water Framework Directive, Natura 2000).

Mainly due to wind driven waves (fine) sediment particles on the bed are resuspended and transported by hydrodynamic flow. High concentrations of suspended sediment particles generally result in low transparency values. Light on the bottom is important for waterplants to grow, gradients between clear and turbid water are important for fish-eating waterbirds to get food.

Given this background of underlying physical and ecological processes and interconnections, currently several measures are studied to improve the ecological state of Lake Marken. These measures involve the construction of structures in the lake that influence the physical processes to improve water quality and ecological state.

The design process of the structures asks for an interactive approach in which different aspects (economical, engineering, recreational, safety for flooding, ecology) from different stakeholders can be combined. For this purpose, for Lake Marken in the Netherlands, a multidisciplinary coupled model exists. However, due to current wall-clock times for scenario runs with the model, interactive sessions (that combines drawing measures with calculations effects with the model with stakeholders) are not feasible yet.

Here we show results of a research project by Deltares, SURFsara, and Cineca (partly sponsored by PRACE - FP7) to enable interactive sessions with the model in the near future.

Methods

The heart of the multidisciplinary model is a silt model for Lake Marken to study hydrodynamics, waves, and sediment in Lake Marken which has been under development by Deltares since 2007. The silt model takes into account wind-driven currents and waves to compute the amount of resuspension and sedimentation for a typical year. See also Figure 1 for a schematic representation of the modelled processes.

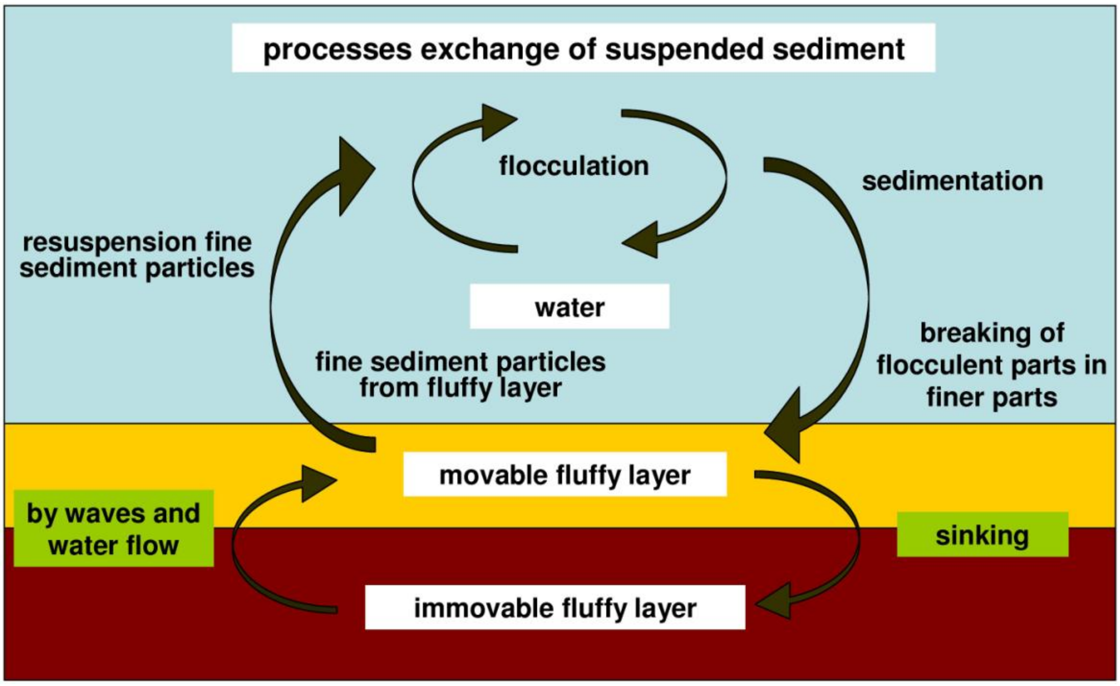

Fig. 1. Schematic representation of processes that are taken into account in the silt model for Lake Marken

In the silt model, for wave effects initially a fetch length approach was used (Genseberger et al., 2011), the same approach is used in studies for other shallow lakes in the Netherlands (Penning et al., 2012). After validation in 2012 with measurements around a large scale experimental structure in Lake Marken the silt model was improved for simulating more detailed measures. For this purpose the fetch length approach was replaced by the third generation wave model SWAN (Booij et al., 1999).

For computing currents the silt model uses the shallow water solver Delft3D-FLOW. Hydrodynamic computations by Delft3D-FLOW are coupled on-line on an hourly basis to the wave computations by SWAN. After this, resuspension, transport of sediment by currents, sedimentation, and light penetration are computed off-line with the advection diffusion reaction solver Delft3D-WAQ. Currently, typical wall-clock times on modern multicore desktops of a coupled hydrodynamic and wave computation are in the order of days. The part with Delft3D-WAQ is only in the order of hours. Therefore we focused on the coupled hydrodynamic and wave computations.

During the project we tried to reduce wall-clock times of the coupled hydrodynamic and wave computations for the silt model by taking into account hardware and software. Here we considered both the separate modules Delft3D-FLOW and SWAN as well as its coupling mechanism Delft3D-WAVE. For Delft3D-FLOW we used previous research on its parallel performance on supercomputers (Donners et al., 2013). The computer codes of Delft3D-FLOW, -WAVE, and SWAN were ported by SURFsara and Cineca to several PRACE infrastructures.

Also an interactive design session was held in the Collaboratorium at SURFsara. The Collaboratorium is a visualization and presentation room that can accommodate up to 7 people with connections for video, audio, network, and power. One side of the room consists of a video wall to display several high-resolution images, animations, and notes. The session can be enhanced with video conferencing, touch interaction, and 3D projection.

The goal of the interactive design session was to experience a.o. benefits of the approach, expectations by users at forehand, and which aspects should be improved. For the session we used a practical case of Lake Loosdrecht (see also Penning et al., 2012). Lake Loosdrecht is a smaller lake than Lake Marken but it has some similar aspects which are of importance for the approach. We used a simplified model based on fetch length with wall-clock times of maximal 4 minutes. Several participants (from landscape design to local authorities) that are involved in current combined environmental and societal projects on Lake Marken joined the session. See Figure 2 for an impression.

Fig. 2. Impression of interactive design session for practical case of Lake Loosdrecht

Results

The coupled hydrodynamic and wave computations for the silt model of Lake Marken were benchmarked and optimized. The original goal of the project was to reduce wall-clock times of a typical one year simulation to about 1 hour to enable the use of the model in an interactive design session. At current state of the art hardware wall-clock times can be reduced up to 12 hours. So interactive design sessions for a typical one year simulation with the more detailed silt model are not feasible yet.

However, the interactive design session yielded a surprising result. The model used for the session is much more simplified than the model of Lake Marken. However, the participants indicated that it really was of benefit for a better understanding of the physical and biological processes and to have a better dialogue and more efficient design process.

Discussion

Based on this main outcome of the interactive design session, we concluded that the more simplified fetch length method is of use for interactive design sessions to have a dialogue with stakeholders about possible measures. More details of these measures should than be studied later on with the more detailed silt model of Lake Marken.

Acknowledgements

We acknowledge PRACE for supporting a part of this research.

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UAV and GIS Integrated Vegetation Analysis of Trasimeno Lake

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Keywords: Environmental monitoring, Unmanned Aerial Vehicles, Geographic Information System, Multispectral, Vegetation Indices

Introduction

Photogrammetric and remote sensing methods based on micro and mini UAV (Unmanned Aerial Vehicle) are nowadays extremely interesting.

These performances are due to the technological progresses in sensors miniaturizing, to the extreme portability of these aircrafts, to the easy driving also by not expert staff. Moreover, the cost much lower than the traditional remote sensing allows the possibility of frequent flights at low altitude also in impervious areas.

This paper deals with the potentiality of using high-resolution multispectral image data acquired by UAV SR-SF6 in order to analyze on a temporal and spatial scale the extension of *Phragmites australis* (or Common Reed) localized in the south of Trasimeno Lake. The *Phragmites australis* influences considerably the ecological balance of the Lake. Indeed the epiphytic microorganisms in the submerged part contribute to both the metabolism of nutrients and the killing of bacteria (Bresciani et al., 2012).

Moreover, the *Phragmites australis* affects the evapotranspiration levels representing a significant contribution to the Lake water balance (Dragoni, 2005).

The use of remote sensing techniques for environmental parameters monitoring and control is in accordance with the goals of Water Framework Directive (2000/60/EC) which defines the environmental quality objectives for the major water bodies.

Materials and Methods

The test area takes place in the south-Est of Trasimeno Lake and it extends for about 11,000 m^2. It is within an important naturalistic oasis nearby S. Savino hamlet and holds one of the most extended Reed beds of Trasimeno Lake. Afterwards a brief description is reported dealing with the UAV SR-SF6, the control software, the sensors utilized, the orthorectification images algorithms, the valuable Vegetation Indices (VI) also useful for the Reed Beds analysis.

UAV and sensors description

Platform UAV SR - SF6

The UAV SR-SF6 is a hexacopter VTOL (Vertical Take Off and Landing) categorized as mini-UAV weighting 3.5 kg with payload 1.5 kg and developed by Skyrobotic of Terni. It is equipped with an autopilot (FMS SR5000) allowing the autonomous vehicle navigation. The autopilot is able to communicate with the Ground Control Station (GCS) over distances of up to 1 km. A suitable control software - installed on a tablet rugged Panasonic with Android Operating System - is connected to the GCS with a hotspot Wi-Fi. The control software enables to let the vehicle through the flight path specified during the mission planning.

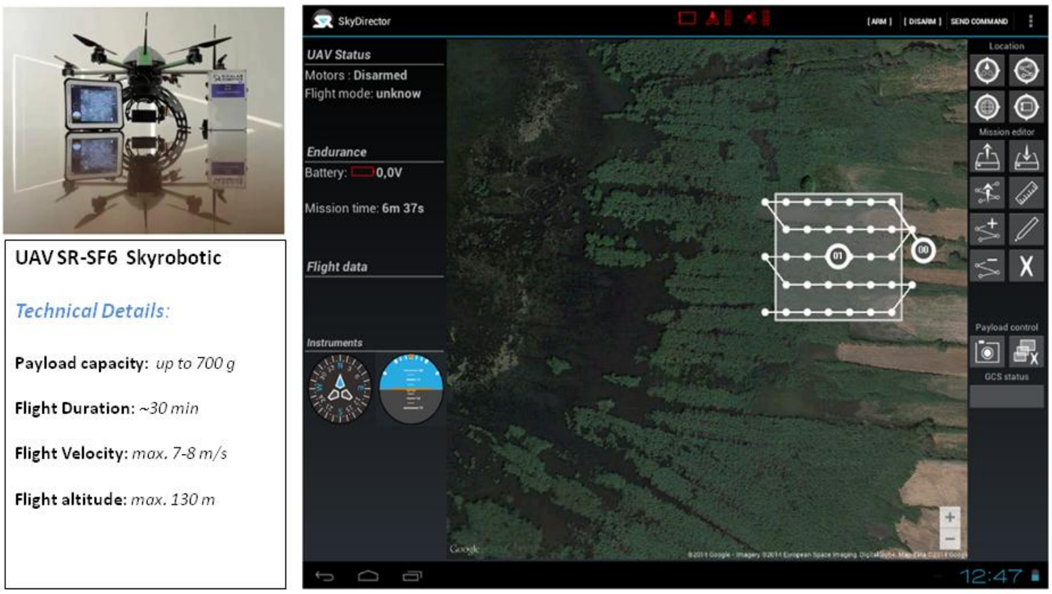

Fig. 7. Basic components of SR-SF6 platform and technical details. On the left, upward: hexacopter, Ground Control Station (GCS), Tablet

equipped with control software for mission planning. On the right: Skydirector, GIS based mission planning software (mission editor). Ortophoto GoogleEarth ®.

In Fig. 7 the mission editor shows highlighted the area photographically covered by the flight, the start point and the central point of the area, the camera positions path. The flight was characterized by constant height and speed, respectively 70 m and 2 m/s and by the acquisition of 24 frames to cover the area. The forward overlap planned was 70% and the side overlap 50%.

Multispectral Camera

The sensor on the vehicle is a multispectral camera ADC Micro Tetracam able to acquire pictures in the RED, GREEN and NIR channel. Afterwards the sensor specifications:

Array Elements	2048x1536
Pixel Size	3.2 μm
Sensor Dimensions	6.55x4.92 mm
Focal Lenght	8 mm
Output	10 bit DCM, 8 bit RAW e 10 bit RAW

Table 1. Tetracam ADC Multispectral Camera - Sensor Specifications

Considering the sensor dimensions, the focal length and the geometric flight characteristics, the field of view (FOV) is equal to 57.3 m x 43 m with a spatial resolution on the ground of 24 mm.

DEM and ortophoto generation

The 3D surface model reconstruction was obtained from single frames using the typical close-range photogrammetry technology, almost consolidated in several commercial software. These technologies are based on automatic orientation process (appropriate operators identify homologous points - tie points - between frames) and on 3D points cloud generation that enables the DEM reconstruction (Lo Brutto & Spera, 2011). The ortophoto generated by DEM was georeferenced using aboard GPS data and without ground control points (GCPs). However, the orthophoto has a not significant error for performed analyses.

Vegetation Indices

Vegetation Indices, generally extracted by satellite imagery, represent a good indicator for monitoring vegetation conditions: health, growth levels, water and nutrient stress...etc., (Silleos et al., 2006). By the combination of Green (G), Red (R) and Near Infrared (NIR) bands different indices can be derived: RATIO, RVI, NDVI, NRVI, TVI, CTVI, TTVI, GNDVI.

Especially, NDVI (Normalized Difference Vegetation Index) is one of the most used index also thanks to the ability to differentiate green vegetation area from other surface types: water, soil,…etc. It relates spectral chlorophyll absorption in the red band with the one in NIR band. It is definitely expressed as the difference between the NIR and the red band normalized by the sum of these, according to the following formula, (Gini et al., 2012):

$$NDVI = \frac{NIR - R}{NIR + R}$$

The index ranges from -1 to 1, with 0 representing the approximate value of no vegetation (Silleos et al., 2006).

Results

Thanks to numerous tests carried out and to the flying characteristics of the hexacopter, it was possible to obtain high-resolution photos without unexpected deformations (rolling shutter) caused by slow acquisition speed of multispectral sensor type (Gehrke & Greiwe, 2013).

The Fig. 8 presents the false colors orthophoto (Green, Red & NIR channel) and NDVI map, obtained by GRASS GIS technology with appropriate functions allowing algebraic operations between rasters, (Neteler & Mitasova, 2008).

The comparison of NDVI Index with the orthophoto shows that NDVI positive values indicate the presence of vegetation, with highest values located at the regions characterized by the highest vegetative and leaf density (NDVI between 0.5 and 1). The areas with negative values (NDVI between -1 and 0) indicate the presence of water.

Once we know the areal distribution of NDVI, GRASS allows the valuation of the areas where the index takes on values in a definite range.

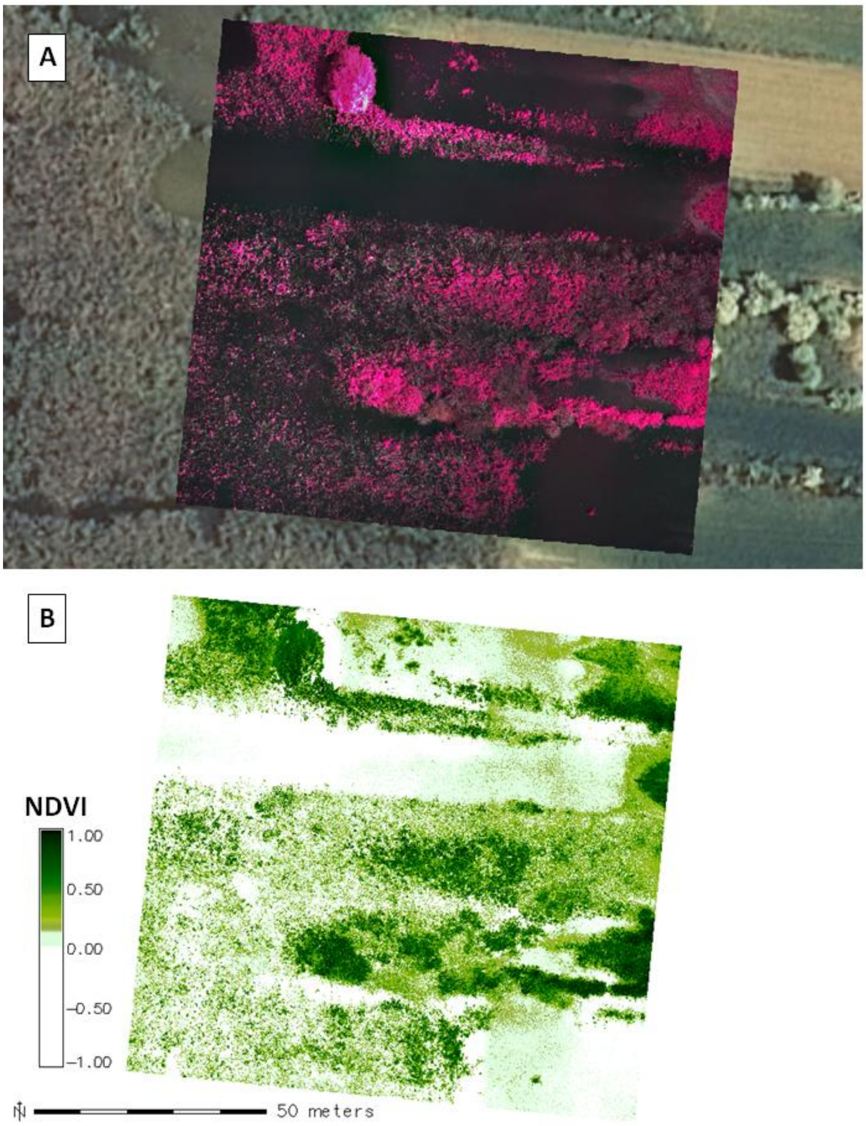

Fig. 8. A – False color orthophoto (R, G & NIR) of test area; B - NDVI map (georeferenced EPSG: 3004)

Discussion

This paper deals with the possible integrated use of GIS technology with high-resolution images acquired by UAV SR-SF6 in order to analyze the environmental parameters describing the *Phragmites australis* (Common Reed) of Trasimeno Lake.

The GIS based overlay of multiple information levels (multispectral orthophotos by drone, satellite orthophotos, vegetation indices maps, DEMs…etc.) allowed a first evaluation of Reed bed extension in the test area.

The planimetric accuracy of the objects was influenced by the georeferencing of orthophoto. In our case, since ground control points were not used, the georeferencing is based on GPS coordinates measured by the onboard receiver. Therefore, the accuracy of the orthophoto is comparable with the one of GPS receiver, expressed as CEP (Circular Error Probable) and equal to 2.5 m. This value that can further decrease if automatic SBAS (satellite - based augmentation systems) corrections are used.

Therefore, the metric properties of measuring device are largely sufficient for vegetation parameters monitoring.

The good accuracy level allows to use the UAV SR-SF6 measurement missions as basis for calibration of larger scale measurements.

Furthermore, the possibility of using the spectral response in different bands allows to quantify the more interesting botanical stage of vegetation cover. Subsequent applications could be implemented to measure the vegetation cover albedo.

Acknowledgements

The authors thank the Skyrobotic s.r.l. for UAV using and for technical support in flights execution.

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LAKE AND HUMAN CONNECTION

Internal waters culture and civility: the Linguistic Atlas of Italian Lakes (ALLI)

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Keywords: italians lakes, geolinguistic and ethnolinguistic project, the linguistic italian lakes atlas

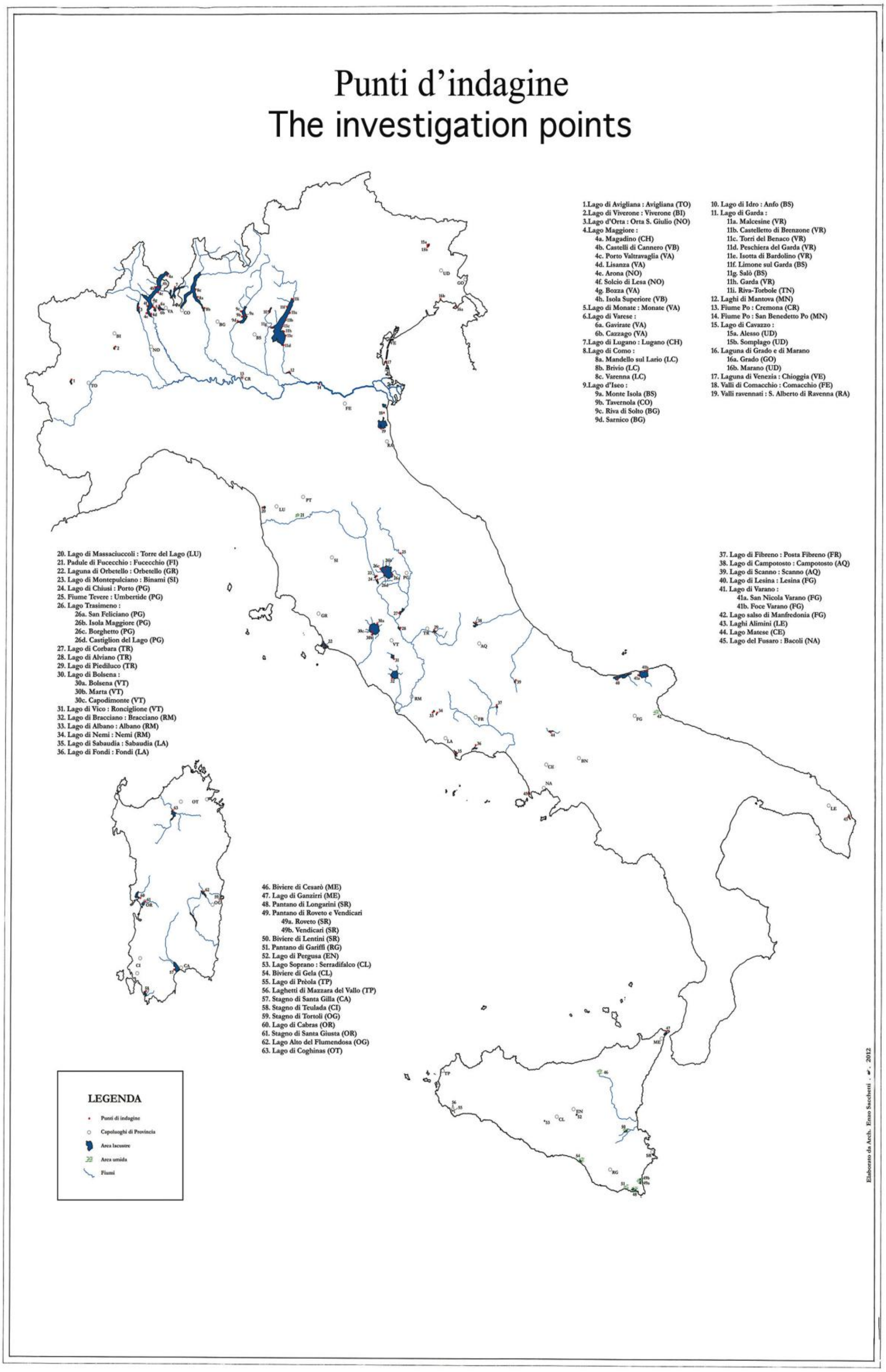
The linguistic Atlas of Italian lakes is a geolinguistic and ethnolinguistic project aimed at collection, documentation and study of life, history and language of all the communities who have lived by the Italian internal waters.
First investigations were held in Umbria and Tuscany during the Sixties/Seventies by the professor Giovanni Moretti, who had given the idea of the project, and these investigations allowed to elaborate instruments and methods for collecting and documenting.
The research program was and is evolved by the central research group, directed at the beginning, by the Cattedra di Dialettologia Italiana della Facoltà di Lettere dell'Università di Perugia. Twelve academics from 12 Italian Universities, engaged in the study of respective areas of appurtenance, participated to the achievement.
The project officially was born in 1982, during the first conference in Castiglione del Lago-Passignano S.T., entitled: "*Language, history and life of Italian lakes"*.
In all the center of documentation, located close to Lake Trasimeno (S. Feliciano di Magione, Passignano) and to the other Italian lakes, the areas of investigation are available and destined also for non specialists, to get knowledge about internal waters culture, to be aware of humid environments and of their multiple aspects.
During the conference emerged the need of extending investigations of the major Italian lakes, using a 524 questions questioner, including different sections: geomorphology, atmospheric factors, sailings, floatages, fishing, fauna and flora.
The linguistics and ethnographics materials, collected in 95 dots of investigations in the 63 humid areas (lakes, rivers, glades, …) in the italian areas, have been examined from different points of view: by the linguistics, anthropologists, historians, archeologists and by all the academics interested in exploring the peculiarity of human-water relationship.
There is a lack of systematic attention towards the internal waters culture in the geolinguistics and ethnolinguisics fields.
Its marginality, its residuality in some areas (due to the ongoing socio-cultural changes and the technological development), the theorical and methodological in-depth analysis, gave the engaged researchers a new point of view.
The extralinguistic reality of ALLI is an essential and key element in the investigation, to understand the linguistic factor not as an isolated phenomenon, but inside the language and culture system. All the linguistics datas available in the ALLI, if examined in the respective semantic field and in the historical-linguistic prospective, could be also comparable in the geografic variation.

The close integration between historical linguistics and dialectology is based on the realization (especially from historical linguistics) that the linguistic alteration can hardly be studied without considering time and space differentiaton.
The data for all surveys have been implemented in a computer file (in which each term is transcribed using three different systems: IPA (International Phonetic Alphabet), CDI (Charter of Italian dialects), Simplified (use of symbols of the Italian with the addition of other conventional), with the aim of creating a database, linked to various Documentation Centers.
In S. Feliciano has been active since 1984, the Museum of Fisheries of Lake Trasimeno, at first sponsored by the Center for Documentation Project ALLI, who oversaw the publication of a publishing series Papers of the Museum of Fisheries of Lake Trasimeno.
With the CD Rom (2000), Fishing Lake Trasimeno in antiquity, E. Gambini, has launched a new line of studies on the Umbrian lake, highlighting the possibilities offered by cross-reading of the archaeological data and the linguistics, in order to achieve a better understanding of the deep and strong roots of the great local fishing tradition, which has offered its best fruits in the Middle Ages with large peaches with fixed installations on the open lake, the so-called bulls.
Such investigations are desirable on the other lakes and rivers in which archaeological and linguistics researches were carried out. Forms of weight with the network in clay, similar to those of Lake Trasimeno, were found, among other things, in the lake of Bolsena and in the Chiana Valley along the Clanis.
The cultural and linguistic system related to the winds, already studied in 1992 by G. Costa in the volume Anemonimi Benacensi, was studied with the focus on Lake Trasimeno, in the volume of C. Cecchini and C. Cencioni (2000), The Winds of Trasimeno and the culture of the fishermen, is enhanced with a new contribution of Costa (2011), in which the author collects and examines the complete vocabulary of the names of twenty Lake Garda, reconstructs the ethnolinguistics taxonomy that organizes the cognitive system, and indicates some of the historical, cultural and linguistic components that underlie the formation of a guidance geodynamic system, which is unique in the Europe.
The semantic field of the winds can be a vantage point for the identification of the mechanisms of language variation and their reflections in the field of culture. The winds, in fact, affect fishing and navigation, as they do not perform the same action on all banks, they favor a plurality of experiences and cultural responses and consequently a complex and articulate semantic field with plenty of lexical variation.
The historical-linguistic and etymological recognition conducted in the volume V. Valente and C. Marinelli (2002) Fishing with the ice in the tradition of Lake Trasimeno, by Valens on the documentation of ancient Greek and Latin and the most recent of linguistic atlases made it possible to delineate the geographical and historical background of the giacchio (network launch) and confirming the widespread use and popularity of the network and the cultural impact in social communities very different from each other, to the point that there are many figures of speech related to the ice which also appear in the sacred texts and literary works belonging to different times and places.
Perspectives and research directions, which are present in the most recent publications of the project can be considered as further information and/or an extension of the themes that

emerged in the many previous contributions and in conference proceedings and meetings of the study.
The CD-ROM Avifauna: the great crested grebe (Podiceps cristatus) and Coot (Fulica atra), names and traditions, are proposed paths of observation of the avifauna of Lake Trasimeno, read through the names of birds; linguistics analysis allows us to discover the importance of this component in the ecosystem of the lake and outline the perception and attribution of value to man. The contribution of Batinti A., Gambini E. (2010), names of systems and fishing sites. Notes of the lake place names, from the analysis of project data ALLI emerge obvious correlations between the names of fishing systems (techniques with fixed installations) and the names of the spaces and surfaces of water, in which they were charged. As a reminder of the historical importance of this connection reference may be made to the presence of Lake Trasimeno, the lexical forms and tuoro Torale in a document of 1074.
By examining the materials used in the numerous publications of various addresses, which constitute the current assets of the project ALLI, Antonio Batinti and Ermanno Gambini, in their last contribution ALLI: Proposal for a route search: Ethno-linguistic and archaeological investigations in humid Italian environments (2004), have verified the possibility of establishing a new light on the complementarity between the ethno-linguistic investigations related to Italian and wet environments, for example, parallel those of classical archeology and especially with the most protohistoric recent acquisitions on settlements lacustrine.

Objectives of the project ALLI

All the data concerning the main subsets 4 (boats, nets, flora, fauna) of the 11 foreseen in the baseline questionnaire will feed into an archive, where the linguistic, ethnographic, historical and geographical aspects will be highlighted relating to the individual lakes, obtained through the held investigations and already published publications. In the CD will be included a selection of about 200 questions in the reference questionnaire that have had answers enough spread all over the Italian territory and therefore comparable. The sample so determined may be analyzed from various points of view, by linguists, anthropologists, geographers, historians, and scholars interested in investigating this area of research.
The road that the Project ALLI intends to follow to achieve a useful result not only for the audience of specialists, but also for the users of the various documentation centers managed by different local authorities of the Trasimeno and other wetlands, in Italy and abroad, is to offer moe targeted products and can be circumscribed.
Do not overlook the contribution that a better understanding of the "culture of inland waters" can offer to those who will be called upon to plan interventions in these special environments. It will become critically useful to tell the story of the complex management of this large laminar lake (Lake Trasimeno), for administrators aware of the special characteristics and economic value of this asset, which will seek to maintain a well-balanced relationship between the exploitation and protection of resources that it has offered in the past in abundance.


Punti d'indagine
The investigation points
1.Lago di Avigliana : Avigliana (TO)
2.Lago di Viverone : Viverone (BI)
3.Lago d'Orta : Orta S. Giulio (NO)
4.Lago Maggiore :
4a. Magadino (CH)
4b. Castelli di Cannero (VB)
4c. Porto Valtravaglia (VA)
4d. Lisanza (VA)
4e. Arona (NO)
4f. Solcio di Lesa (NO)
4g. Bozza (VA)
4h. Isola Superiore (VB)
5.Lago di Monate : Monate (VA)
6.Lago di Varese :
6a. Gavirate (VA)
6b. Cazzago (VA)
7.Lago di Lugano : Lugano (CH)
8.Lago di Como :
8a. Mandello sul Lario (LC)
8b. Brivio (LC)
8c. Varenna (LC)
9.Lago d'Iseo :
9a. Monte Isola (BS)
9b. Tavernola (CO)
9c. Riva di Solto (BG)
9d. Sarnico (BG)
10. Lago di Idro : Anfo (BS)
11. Lago di Garda :
11a. Malcesine (VR)
11b. Castelletto di Brenzone (VR)
11c. Torri del Benaco (VR)
11d. Peschiera del Garda (VR)
11e. Isotta di Bardolino (VR)
11f. Limone sul Garda (BS)
11g. Salò (BS)
11h. Garda (VR)
11i. Riva-Torbole (TN)
12. Laghi di Mantova (MN)
13. Fiume Po : Cremona (CR)
14. Fiume Po : San Benedetto Po (MN)
15. Lago di Cavazzo :
15a. Alesso (UD)
15b. Somplago (UD)
16. Laguna di Grado e di Marano
16a. Grado (GO)
16b. Marano (UD)
17. Laguna di Venezia : Chioggia (VE)
18. Valli di Comacchio : Comacchio (FE)
19. Valli ravennati : S. Alberto di Ravenna (RA)
20. Lago di Massaciuccoli : Torre del Lago (LU)
21. Padule di Fucecchio : Fucecchio (FI)
22. Laguna di Orbetello : Orbetello (GR)
23. Lago di Montepulciano : Binami (SI)
24. Lago di Chiusi : Porto (PG)
25. Fiume Tevere : Umbertide (PG)
26. Lago Trasimeno :
26a. San Feliciano (PG)
26b. Isola Maggiore (PG)
26c. Borghetto (PG)
26d. Castiglion del Lago (PG)
27. Lago di Corbara (TR)
28. Lago di Alviano (TR)
29. Lago di Piediluco (TR)
30. Lago di Bolsena :
30a. Bolsena (VT)
30b. Marta (VT)
30c. Capodimonte (VT)
31. Lago di Vico : Ronciglione (VT)
32. Lago di Bracciano : Bracciano (RM)
33. Lago di Albano : Albano (RM)
34. Lago di Nemi : Nemi (RM)
35. Lago di Sabaudia : Sabaudia (LA)
36. Lago di Fondi : Fondi (LA)
37. Lago di Fibreno : Posta Fibreno (FR)
38. Lago di Campotosto : Campotosto (AQ)
39. Lago di Scanno : Scanno (AQ)
40. Lago di Lesina : Lesina (FG)
41. Lago di Varano :
41a. San Nicola Varano (FG)
41b. Foce Varano (FG)
42. Lago salso di Manfredonia (FG)
43. Laghi Alimini (LE)
44. Lago Matese (CE)
45. Lago del Fusaro : Bacoli (NA)
46. Biviere di Cesarò (ME)
47. Lago di Ganzirri (ME)
48. Pantano di Longarini (SR)
49. Pantano di Roveto e Vendicari
49a. Roveto (SR)
49b. Vendicari (SR)
50. Biviere di Lentini (SR)
51. Pantano di Gariffi (RG)
52. Lago di Pergusa (EN)
53. Lago Soprano : Serradifalco (CL)
54. Biviere di Gela (CL)
55. Lago di Prèola (TP)
56. Laghetti di Mazzara del Vallo (TP)
57. Stagno di Santa Gilla (CA)
58. Stagno di Teulada (CI)
59. Stagno di Tortolì (OG)
60. Lago di Cabras (OR)
61. Stagno di Santa Giusta (OR)
62. Lago Alto del Flumendosa (OG)
63. Lago di Coghinas (OT)
LEGENDA
Punti di indagine
Capoluoghi di Provincia
Area lacustre
Area umida
Fiumi
Elaborato da Arch. Enzo Sacchetti . 2012

Telling Italian Lakes in Newspapers A Semiotic Approach to the Narrative Representation of Lakescapes

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Keywords: lakescape, newspaper, narrative, semiotics, visual rhetoric

Introduction

Lakes have had several representations in the world of art, film and literature, which have often created an "imaginary" where lakes are, from time to time, a place of reflection and a pause in narration or, conversely, a place of action.

But what about the representations of lakes in the language of journalism?

To giving an answer at this questions we starts from the empirical methodology of textual research, putting together samples of journalistic texts and analysing the processes of "theming" (lexical and visual isotopic chains).

This paper aims, therefore, to provide a taxonomy of the imaginary around lakes, trying to define possible contextual labels associated to it and the actions that readers consider consistent or likely within these labels.

Methodology

The study of the narrative context, in which the lakescape is placed, allows us to better define the issues that are associated with it and the narrative role played by the lake. In this way, the analysis provides us with results related to the collective imaginary associated with lakescapes.

To describe such collective imaginaries, our study involves the construction of a diachronic sample of Italian journalistic texts. This sample is made with the application of two search criteria: a qualitative one, based on a search of lemmas (a search in digitalized archives using as search keys terms related to the semantic field of lakescapes) and a strictly quantitative one (restricting the search to the following areas: "title", "sectional title", "title header" of the major Italian newspapers).

Two types of analysis are applied to the samples of texts:

The study of narrative structures;

The reconstruction of the cognitive attitude linked to narrative structures.

Case study

As an example of our analysis we present a small case study carried out by a random search on digital archives of three major national newspapers (*La Repubblica*, *Corriere della Sera*, *La Stampa*). The case concerns the journalistic representation of two Italian lakescapes: The Lake Trasimeno and The Lake Garda.

In both cases it is possible to outline the process of theming related to the lakescape identifying four main semantic fields, each with different semantic and passional valuations: tourism, habitat, history & culture, and crime.

The semantic field of *tourism* is characterized by semantic values derived from the opposition between the polarity of the beauty and the polarity of the ugliness. In some cases the contrast between these two values is thematized, especially in articles with a political significance, that aim to raise the awareness of local administrators to the proper exploitation of the lakescape as an economic resource linked to the tourism industry. It is a very broad set of issues ranging from politics, economy and employment up to related issues such as food&wine, art and music. The passional tone of tourism semantic field can be both euphoric (positive) in relation to the success of the lakescape as a tourist site, and dysphoric (negative) in relation to failure.
The semantic field of *habitat* is closely related to the semantic field of tourism, even if it has significant differences in the cases of the "scientific presentation" of the lakescapes, such as, for example, the design of the Idroscalo on Lake Garda, or the relationship between the construction of high speed railway lines and the Garda area. These articles deepen technical and scientific issues, often with a popularizing intention. In these cases, passionate tones are absent, because articles tend to be objective and to avoid the passional entanglement of the readers.
Also the semantic field of *history & culture* is closely related to the semantic field of tourism, but it shows specific themes that in the majority of cases involve the historical reconstruction of the lakescape. In these cases the lakescape is not only a touristic site but a cultural site. Consider the case, for example, of the archaeological studies related to the Battle of Trasimeno and the wars between the Romans and Carthaginians. The passional tone of these articles ranges from a euphoric participation (positive) in the case of success of the historical research and a scientific detachment (passional neutrality) in the case of purely scientific illustrations of the lakescape as a cultural site.
The semantic field of *crime* departs almost completely from the background related to tourism, habitat and history. While the previous three semantic fields have a political tinge, with concrete actions to exploit the place, the semantic field of crime tends to emphasize noir issues related to the lakescape, in most cases inspired by incidents of crime to build fictional worlds in which shades of mystery, magic and danger are attributed to the lakescape. In this case, the passional tone is totally dysphoric (negative).
There are different plots corresponding to each of these theming processes and they can be categorized into two main types: "*plots of reflection*" and "*plots of action*". We call "plots of reflection" stories that see the lakescape as a place of action, a scenery or environment more or less characterized by the immobility of the inanimate place, which does not act. On the contrary, in "plot of action" the lakescape is not limited to be a scenario of actions, but it plays a narrative role.
For each semantic field, finally, it is possible to distinguish different strategies of enunciation. The cases of topics related to tourism and culture are generally associated with a search for complicity between the newspaper (author of the article) and the reader, which is expressed by direct pronouns (us/you, us/you and me/you). In the case of issues related to the habitat, an objectifying style that uses the pronouns of the third persons or impersonal formulas prevails. In the case of crimes the style of enunciation is varied: sensationalistic and direct in the initial phase or during the disclosure of unexpected information, detached and indirect in the phases of description or summarizing.

In relation to the narrative strategies of the texts, the reader takes two main cognitive attitudes in front of the lakescape, which probably he/she tends to keep even in front of other water landscapes: the attitude of the *scout* or the attitude of the *investigator*. These are two very synthetic mental *schemata*, which provide for many possible actions. In the *frame* of the scout, the reader looks at the lakescape with curiosity, assuming as a possible action settlement, knowledge, and identity construction.

This is a typical frame of the reader aroused by newspaper articles that speak about lakes as places for tourism and culture.

In the *frame* of the investigator, the reader looks at the lakescape with suspicion, assuming as plausible actions the responses to threats.

This is a typical frame of the reader aroused by newspaper articles that speak about lakes as places for crime stories or adventure in a unknown habitat.

Conclusion

The perception of lakescapes, in the collective imaginary of newspaper readers, is conditioned by the narrative strategies adopted in the plot about the lakescape, perhaps to a greater extent than the strictly scientific knowledge of the lakescape. Analyses such as our study, therefore, are useful in policy planning and for the proper orientation of the general public, providing a balanced point of view about reality less affected by the processes of rhetorical manipulation of information.

In the case of lake Trasimeno, for example, the prevalence of theming related to the semantic field of crime may have a negative impact on the development of the local economy related to tourism. In fact, our research on the full sample shows a higher score (45 %) associated to the semantic field of tourism. However, the number of occurrences referring only to Lake Trasimeno in the headlines associated to "crime" is much higher. By filtering on titles on Lake Trasimeno the highest percentages of results falls in the semantic field of “crime” (about 70 %) and rest in the semantic field history & culture (30%). The result is rather disconcerting considering the fact that lake Trasimeno should be known worldwide as the site of a famous battle in Roman history, therefore as an archaeological site rather than a scene of crime or accidents.

The so called Behavioral Sciences should certainly include research oriented to the study of languages and modes of processing and dissemination of information. This kind of analysis could support the dissemination of scientific knowledge or the application of knowledge in terms of structural projects, providing the necessary narrative strategies to make acceptable redesign operations on landscapes, and new points of view about lakes.

Tourism

- *Maschera dopo sole sul Lago di Garda (Corriere della sera)*
- *Anello ciclabile attorno al Garda siglata l'intesa tra tutti i territori*
- *Le stelle Michelin brillano sul lago ormai diventato tempio dei gourmet*
- *Turismo e innovazione così le nuove generazioni fanno grande il Garda*
- *Turismo, Garda superstar Iseo e Franciacorta in calo*
- *Il Garda alla ricerca della stagione perfetta*
- *Al lago Trasimeno la settimana del viver lento*
- *Musi fo sunset. Il bello del Trasimeno un festival a misura d'uomo (e di lago)*

45%

Habitat

- *Desenzano, si punta all'idroscalo per cambiare il volto al lungolago*
- *Garda, un sogno chiamato Idroscalo*
- *Garda, rientra l'allarme alghe tolti i divieti*
- *Il Garda scrive a Renzi: rivedere il tracciato Tav*
- *Vietati i bagni nel Trasimeno*
- *Lago di Garda si aggrava l'emergenza*

15%

History & Culture

- *Artisti del palato e della culturainsieme per il Garda*
- *A spasso nel tempo sulle rive del lago Trasimeno. A Tuoro cena del rione Colonna e a Castel Rigone la festa dei Barbari*
- *Trasimeno e l'ossaia di Annibale*
- *Annibale torna sul Trasimeno*
- *In riva al Trasimeno. Una stonehenge del nostro tempo.*
- *Migliaia di uomini peduti dal nemico in vari attacchi a sud del Trasimeno*
- *Il Duce in volo a Castiglione del Lago.*

10%

Crime

- *Nella cassa in fondo al Garda c'era il corpo della pornostar*
- *Medico annega nel lago Trasimeno*
- *Tredici signore annegate nel lago Trasimeno*
- *Due figli dell'industriale Marelli annegano con un amico nel lago Trasimeno i tempesta*
- *Si capovolge un'imbarcazione al motore e sei gitani muoiono nel Trasimeno*
- *Ogni casa di Castiglione del Lago visitata dalla morte*

30%

Fig. 1, Theming of the lakescape in the headlines of Italian newspaper.

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Basin management for protection of a tropical lake: Exploring alternatives

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Keywords: Soil erosion, siltation, lake storage, land use, lake ecology

Introduction

Lake catchment land use pattern exercises great influence on the lake ecology. Siltation in the lake resulting from erosion of soil from agriculture field in the catchment causes irreversible damage to the lake ecology. Alternative land use to the present agriculture, needs to be identified. The present study has been done on a typical tropical lake (Ramsar site) in central India. It has maximum water spread area of 32 km^2 with average depth of 3 m. It is bounded between the latitudes $20^0$1 0'-$23^0$20' and longitudes $77^0$15'-$77^0$25'. It is drained by the 365 sq km watershed, with average rainfall of 1200 mm. Approximately 80% (280 km^2) catchment area is used for agriculture. This lake is a major source of potable water supply to the city. In case of average rainfall the water supply from the lake is 29 million gallons per day (MGD). About 40% of the city population is still dependent on Upper lake for drinking water supply. With the increasing population of the city, the projected demand of water was calculated as approximately 344 MLD for 2011 with population of 2 million that is increasing at 3.5% yearly.

Environmental problems affecting the lake ecology

Soil erosion and siltation: Soil erosion from the agriculture land has adversely affected the lake storage capacity. Upadhyay et al (2012) reported siltation rate of 1.4 mcum and predicted lake life of 83 years. This would mean mobilizing other water resources to meet the increasing water demand of the population at additional cost. According to a study (SAPROF, 1994) the silting rate has been estimated to be 1 to 2.58 cm per year on an average. The estimated sedimentation rate from the catchment area is in the tune of 3.67 ha m/100 km^2/year. The storage capacity of the lake was reduced by about 5 million cum. About 6.6 km^2 area of the lake near Kamala park was deposited with silt and sediment to an average thickness of 0.75 m.

Agrochemicals use: Agricultural runoff adversely affects the trophic status of the Upper lake (Mishra, 2006). The nutrient level is causative to increased primary productivity in the lake as exhibited by excessive growth of macrophytes (Shrivastava et al, 1992). This also leads to algal growth, high coliform and turbidity in the lake (Shrivastava & Joshi, 1994,Vipin et al, 2009 and Valech et al. 1995).

Addressing the soil erosion in catchment & siltation in lake

Organic farming

Lake conservation authority and Winrock international made some initial efforts to explore the feasibility of this eco friendly approach as an attempt to provide solution. Organic farming proposed in the catchment encountered several constraints due to land holding pattern, costing /pricing of the agro produce, the international requirements for certification of the land, marketing of produce and the other relevant infrastructure required to be in place.

Desilting

Under the Bhoj wetland conservation project, removal of silt was one of the sub projects identified for ecological restoration and to create additional storage capacity of the lake equivalent to 7 mgd water supply. Although the post project assessment done by external evaluators Masahisa Nakamura,Victor Muhandiki and Thomas Ballatore indicates shortfall in achievement of targets in several subprojects.

Watershed treatment

To mitigate inflow of silt, agricultural residues and other wastes into the lakes, 73 check dams made of loose boulder/Gabion structures having a cumulative silt trapping capacity of about 0.35 million cum have been constructed across 28 inlet channels in the catchment, the capacity of these structures is far below the requirement (1.4 mcum) and is less than quarter of the total silt load that the lake receives annually. Restoring these structures stipulates cost and recurrent in nature. The upstream group of the people would be opposed to bearing any such cost. This conflict becomes major constraint in catchment management.

Identifying alternative land use to address the erosion problem

Agriculture is becoming less profitable due to several reasons, water availability being important among other factors. For aforestation or reforestation of the agriculture land, there seems to be no inclination of the farmers as this does offer potential livelihood alternative to them. It therefore becomes necessary to explore acceptable alternatives to agriculture in the catchment.

It is therefore important to explore possibility to convert land use to urban land use to different degrees depending upon how much of pollution originating from agriculture is required to be reduced. The proposed land use can be a suitable combination of residential and institutional infrastructure development along with forest and greenery spread over the area in consideration. Both sewage and solid waste by prevention and reuse (Wolsink, 2010) may be more professionally managed. Non point source of pollution requires stringent measures to be enforced by the authority in the region. Lake Biwa inhabits considerable human population in its catchment but has very effecient governance that has demonstrated protection lake ecology from adverse impact arising from land use. Owing to high opportunity cost and the preference shown by the people/developers in this area, a separate tax structure can be thought of in order to mobilize extra financial resources. Population/ density can be of lower level so as to sustainably manage the environment of the catchment. System of governance in the area may be different for powers and authority vested with the agency controlling the area. Decision making should be more transparent and involve stakeholders. Process of consultation should precede the decision taken developmaboutent and enforcement of law in the region with the objective to effectively manage the environment of the area.

The proposed land use change may effectively address the problem of erosion of soil and the resulting siltation apart from eliminating inflowing agrochemicals in surface runoff that empties into the lake.

Adopting roof top rain water harvesting having highest run off coefficient of 0.7 and upto 80% collection efficiency of water for aquifer recharge and also for runoff to reach the lake, shall be an environmental friendly approach. The catchment under the proposed project should yield approximately more than 13 mcum runoff volume with average precipitation of 1000 mm where as in the present condition this value should be approximately 0.37 mcum with run off coefficient of approximately 0.1 for green field. Natural drainage in the area requires to be protected as this takes water to the lake as surface runoff. The arising food security issue is serious and needs to be addressed as it is a major concer of the expanding population in the area would need this security. A trade off may be reached by compromising with reduced rate of land conversion for residential purpose in other areas around Bhopal. This should compensate the resulting loss of agriculture production from land conversion in lake catchment.

Land area can also be used for solar energy production and the water collected from the panels may be harvested easily and this may be source of livelihood for the catchment inhabitant.

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The project for the lakeside landscape as explanation of variability

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Keywords: project, cure, ecology, fickleness, alternation, change, variability

Premise

When the earth's crust is considered as a whole figured as plains, elevations, depressions, water basin and more different configurations of parts, territory can be evaluated as malleable spatial material. In this scenario, multifarious factors work as driving force and able to modeling earth's surface layer. The earth is constantly changing and water, volcanic eruptions and wind are key factors in the coevolutionary process. The resulting situation may assume any kind of formal characteristics in a topological sense: vertex, bowls, borders and sweeps. Architecture is part of breaking up, organization and re-building process of the matter, it aim to do a continuum that exceeds distinction between nature and artifact.

In this framework, forms in which water appears on our planet highlight its particular conformation. These forms are various and make up real and iconic space meaning richness and variability. In this way water-based forms are start point of life development. Historically seaside areas, rivers, falls, lakes and wetlands were the best places for human settlements.

Western civilization gradually deluded itself in thinking to control nature, to model her according to settlement rules, consequently society thought to be independent from environmental conditions. Through technical control, modern positivism tried to win the challenge to transform landscape without evaluating negative environmental feedbacks. The construction of landscape space is inseparable from particular ways of seeing and acting. Damming and redirecting rivers, reclaiming wetlands, dwelling deserts, has generated in a few time significant implications on the ecosystem (Toppetti, 2012, 2013).

Project as cure

Relationship between water and society evolved into various splitted fields of specific interest expelling cohesive vision. The result was the separation of waterscape amenities among defense and security fields, vital needs, aesthetic appearances considered in terms of pure visibility. Furthermore it was possible to defend settlements also without water presence, it was always possible to admire lakes and rivers although contaminated.

Rewriting the terms landscape and environment in a contemporary, global perspective and nowadays widely shared, we can consider waterscapes as emblematic of an holistic vision, in which new coalition are experienced between mankind and nature. It is clear how many of the works accomplished in the past, when everything seemed to be admitted, show now their limit in facing environmental feedback they created and which are before everyone's eyes.

Usually those projects considered nature as something stable, so instability was something unusual. Variations of the extension of flooding areas was considered a problem as well as shifting rivers that periodically modify their flow, because it was commonly considered necessary to settle and exploit every space, even if it was borderline in terms of safety and healthiness, instead of leaving tolerance allowances and controlled spaces in which nature is untouched. It's been a long time since ecology introduced the concept of evolution and invariability of processes, thanks whom landscape main structure can change from fixity to mobility.

In this sense, contemporary landscape project increase aforesaid key points and traces its areas of application as a “new regulation tools” that officiates natural coevolution process. New regulation tools works in sync with process for to re-establish balance although necessarily unstable. That is to say, it is indispensable to put in place measurements for turning in positive the “territory deformations” by suggesting legitimate compatible with the rules of long-term natural cycles. A project aimed as “landscape care” (Emery, 2011) that means works for configuring steps level of alteration controlled by introducing main question of responsibility towards future arrangement.

What does this mean referring to landscape, in particular about lakescape? Too often, the adoption of these instances involves into univocal interpretation that once again wreaks the return at a presumed state of nature, lost whit human intervention. This is the only viable route to take. It's not a coincidence that also the most advanced European normatives, more or less explicitly, hitherward points (cf. in particular DQA 2000/60CE).

Specifically Lakescape

Specifically in lakescapes, the theme of project as "therapy" materializes itself in ecological and environmental maintenance and requalification, through a trans-disciplinary approach in which specific technicism and sector-based methodology make way for an integrated vision. Even if it has been too often taken as central objective, re-naturalization seems to be the only way forward. But thinking that complex ecosystems scared by unavoidable anthropization could be brought back into wild nature condition is short-sighted, unable to imagine a mature habitat in which the presence of mankind acts as completion, in order to direct the great natural project.

So the question shifts on legitimate and effective action based on seriously dynamics of environmental co-evolutionary knowledge, oriented for an overall environmental sustainability, eclectic and inclusive. Sometimes it may also coincide with an increase of natural requirements. Quality is the discriminating factor, expressed in complementary and multifarious ways as the reshaping of land topography, spatial arrangement of public space, capacity of technical works aimed as “inflection” within linear landscape modification. Renewed water protagonism as project material is the second main factor, more relevant and specific, it is base point of the proposed scenario. Water gives an important quality to the landscape: the variability, expressed in terms of spatiality and figurability (Lynch, 1960). Water is a medium of the fickleness of landscape, the project will take water not only in its aesthetical or functional terms, but it evocates water’s reminiscent and poetical power and its adapting and overboarding force. Best practices in the world reach significant results, harbingers of future developments. Instead in Italy policies and planning practices are still fixed on traditional measures and old rhetorics (Palermo, 2009) based on technical and engineering approach. It is a matter of comforting strategy that are incline to curbs problems, perpetuates mistakes, unfit to carries out the new expectations of sustainable transformation. Therefore the local government, that controls and manages the land and water planning, pursue choices pertaining to outdated measures.

Lakeskape project as expression of fickleness (oppure “Lakescape project as nexus between flickleness and starting process”)
Work intends to present some theoretical considerations and the possible operational impacts related to the instability of the water landscapes from an experimental reflection carried out in the academic field on the case of Barrea Lake which is located in the Abruzzo National Park, outlining the topic in the current scientific debate, and in relation to some best-practices identified in the European panorama and beyond. The wetland that includes the basin and the ecotonal zones is inserted since 1976 in the protected areas list of the Ramsar Convention. The lake, formed in 1951 by a dam construction across the Sangro River, as many basins aimed for energy use, has a variable water regime. The dry up in summer is perceived as a source of impoverishment for biodiversity and as a negative factor for the overall quality of the landscape for instance to jeopardize the tourism economy of the area. This condition induces the Municipality and the local population to support the project for the construction of a new earthen dam, which would guarantee the permanence of a small upstream water reservoir, compromising the basin unity and its specific characters now consolidated. In alignment with the research and accomplishments, of major interest, experimented on similar situations in recent years, the topic of alternation is not considered as criticism but as a resource, in terms of delivery of ecosystem services and for the quality of the landscape in general, to be taken as a value (ecological and economic) within a new design vision integrated by the lake landscape[1].

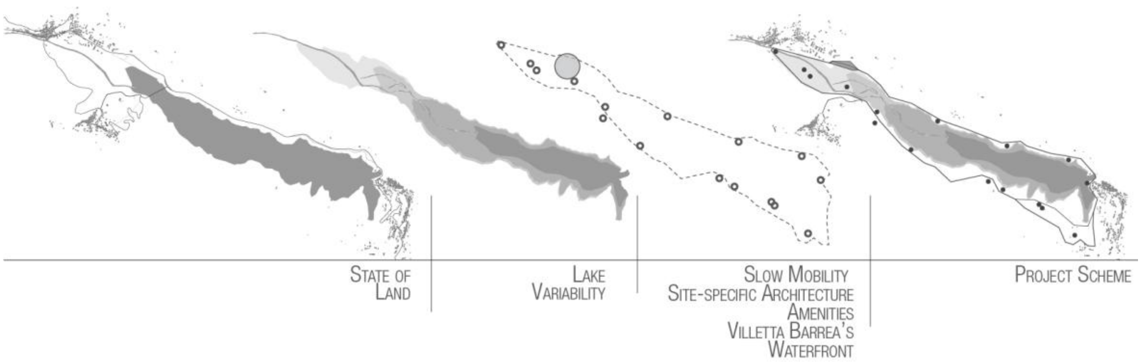

Fig. 1. Layers of landscape project

[1] The case study refers to second degree thesis in Landscape Architecture (School of Architecture, Sapienza University of Rome) entitled “Filtering linescape. New Villetta Barrea’s lakeside waterfront”. Thesis edited by Federico Di Cosmo in collaboration with Professor Fabrizio Toppetti. Work is fully explained in “Fickle lakescape project” Poster in World Lake Conference 15 Perugia

Fig. 2. Digital representation of interplay within projected areas and lake flood. In this case submergible island works as informal recreational space and landamark.

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The diachronic evolution of the Western Greece's Lagoons

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Keywords: Diachronic evolution, lagoons, Western Greece

Introduction

1 The lagoons of western Greece

The Araxos lagoon, lake Prókopos, the marsh of Làmia and the lagoon of Kotychi to the South, in the Prefecture of Elia, make up the chain of wetlands of the western Peloponnese, and along with the lagoon of Mesolongion-Aitoliko constitute the main wetlands of western Greece.

The Araxos lagoonor "Kalogria" (*the nun)* or "Papa", covers an area of 380 ha with a depth ranging between 0,5-3,5 m.

Today, according to the Greek legislation, dated April 29 2009, the area of the Kotychi and Strofylia lagoons has been declared as a protected zone (Figure 1). The map shows that there are two major zones with different level of protection. i.e. Zone A is protected by NATURA 2000 agreement, while Zone B is protected by the Greek legislation, which has characterized this area as a national Park.

Figure 1. National park of Kotychi and Strofylia wetlands

The strategic development

The strategic location of the lagoons had been recognized by the ancient inhabitants of this region. The prehistoric citadel of Teichos Dymaion occupies an imposing rocky hilltop at the southernmost tip of the so-called “Mavra Vouna” (black mountains), between the lagoons of Prokopos and Pappas, near the village of Araxos. Archaeological research has shown that human occupation here began in the Late Neolithic (mid-4th millennium B.C.) and continued almost uninterrupted into the period of Venetian occupation (Mastrokostas 1965, Kolonas 2006). The first significant settlement remains date to the Early Helladic period (ca. 3000 – 2000 B.C.), but the most prosperous and period was the Mycenaean, (13th - 11th cent. B.C.), when the settlement expanded and the emblematic cyclopean fortification was erected (around 1300 B.C.)[2], to strengthen and symbolize the defensive character of the site (Driessen 1999)[3].

All the above can be described as different aspects of a broader bio-cultural environment, in the sense that Maffi[4] has introduced. In the case of Teichos Dymaion we have a combination of biological and cultural factors that were in action side by side[5].

Teichos Dymaion can be seen as a prime example of a site strategically located in order to make the most of what its setting had to offer, both in terms of subsistence as well as of culturally oriented possibilities (Gazis 2010).

The socioeconomic evolution

During the Bronze Age and specifically during the Mycenaean period (ca. 1600-100 B.C.), we find organized settlements, as a consequence of the combined marine and terrestrial resources. Easy access to water and to fertile land were crucial for the advance of agriculture, animal husbandry, cultivation of trees as well as the commercial activities with the towns of the Western Greece.

The geomorpological evolution of lagoons

Diachronically, the main creators of the Messolonghi lagoon were the two big rivers of the region, Acheloos and Evinos.In Table 1 the diachronic evolution of the alluvial deposits are given. The values of this table were computed based on Villas 1983 after overlaying 2 maps over a current map using GIS method Hatzopoulos, (2008).
It is found that the present protected area includes 22627.7 Ha having increased by 212% in relation to the past due to the soil material brought Acheloos river (Diamanti and all., 2014).

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[2] A number of factors that had led to the choice of specific locations for the construction of Late Helladic fortifications have been outlined by Karageorghis 2001.

[3] For a review of the site's history and role see Gazis 2010.

[4] L. Maffi, defines *biocultural diversity* as "the diversity of life in all its manifestations: biological, cultural, and linguistic — which are interrelated (and possibly coevolved) within a complex socio-ecological adaptive system." (Maffi 2007). She also notes that " … the emergence of this field came from the observation that all three diversities are under threat by some of the same forces and from the perception that loss of diversity at all levels spells dramatic consequences for humanity and the earth." (Maffi 2005).

[5] Certain geographic areas have been positively correlated with high levels of bio-cultural diversity, including those of low latitudes, higher rainfalls, higher temperatures, coastlines, and high altitudes.

Period	Hectares [Ha]	Difference [Ha]	Change %	Total Change [Ha]	Total Change %
1900-2000 A.D.	32627.7	0	0.0	22170.3	212.0
1700-1800 A.D.	29355.5	3272.2	10.0	18898.1	180.7
1200-1500 A.D.	28880.5	475	1.6	18423.1	176.2
800-1100 A.D.	26148.7	2731.8	9.5	15691.3	150.0
100-400 A.D.	23027.2	3121.5	11.9	12569.8	120.2
700-400 B.C.	17388.1	5639.1	24.5	6930.7	66.3
2000-1600 B.C.	10457.4	6930.7	39.9	0	0.0

Table 1. The evolution of alluvial deposits in Acheloos River Delta, since 2000 B.C.

The complex of the lagoons covers an area of 15000-22,627.7 ha, Hatzopoulos, (2008), and includes the wider area of the wet land system, the coastal ecosystems and the swamps. The whole wetland system includes 42% of the lagoons on a national level, and the Messolonghi lagoon is one of the greatest in Greece as well as in the Mediterranean basin.

Conclusions

The study of the evolution of Western Greece's wetlands (lagoons, rivers, lakes and marshlands) has disclosed the following:

These wetlands have played, and continue to play an important role in the economic, social and cultural development of this part of Greece.

The prehistoric citadel of Teichos Dymaion was the only fortified mycenaean acropolis in western Greece, and the emblematic cyclopean fortification (erected around 1300 B.C.)[6], strengthened and symbolized the defensive character of the site (Driessen 1999)[7].

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LAKE BASIN MANAGEMENT EXPERIENCES AND CHALLENGES

Towards practical measures for improving the ecological state of lake Marken by combining in depth system knowledge with stakeholder aspects

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Keywords: shallow lake, Water Framework Directive, suspended sediment, ecology, stakeholders

Introduction

Lake Marken is a shallow lake in The Netherlands with an average depth of about 4 meter and a surface of 700 square kilometer. For this lake, high suspended sediment concentrations result in reduced ecological values and prevent goals and standards from being met (Water Framework Directive, Natura 2000). Mainly due to wind driven waves (fine) sediment particles on the bed are resuspended and transported by hydrodynamic flow. High concentrations of suspended sediment particles generally result in low transparency values. Because the lake is largely artificial and shallows and transition zones are underrepresented, this aspect dominates the ecology of the lake and diversity is low. Light on the bottom is important for waterplants to grow, gradients between clear and turbid water are important for fish-eating waterbirds to get food. Waterplants reduce resuspension and provide habitat for young fish and many species of invertebrates, that in turn can feed birds. These are the main underlying physical and ecological processes and interconnections. With this knowledge, a practical measure to improve the ecology that is currently studied is the construction of sheltered areas in the North West part of Lake Marken. Construction of dams, islands, and shallow areas will influence the physical processes to improve water quality and ecological state. The study of the required size, shape, and location of the structures is being carried out. Next to the in depth knowledge of physics (via a coupled silt model for Lake Marken) and ecology, this also included an interactive approach with different stakeholders for aspects other than ecological impact (like implementation costs, engineering, recreation, and safety). Here we will show how the combination of knowledge of the underlying physical and ecological processes and the interactive approach with stakeholders worked out during the study.

Methods

The following methods were used:

a coupled silt model for Lake Marken to study effects of the structures on hydrodynamics, waves, and sediment,

ecological expert judgements by interpreting results of silt model simulations with in depth ecological expert knowledge to assess the ecological impact of the structures, and an interactive approach with different stakeholders for other aspects (like implementation costs, engineering, recreation, and safety).

The study had to follow formal rules for design and realization of infrastructural projects by the Dutch public works about the objectives and how these objectives were quantified. Therefore, at the start of the study, some effort was needed to specify the outcome of the study, how this was going to be measured, and how these results were going to be translated and evaluated such that policy makers can use them.

For the interactive approach with different stakeholders four working sessions were hold during the study. In these sessions we discussed the aim and necessity of the measures and asked the stakeholders for their interests, wishes, and suggestions. Figure 1 gives an impression. The first two sessions resulted in three possible scenarios. After the fourth session we had enough information to evaluate them.

Fig. 1. Impression of interactive session with stakeholders to discuss location, type, shape, and size of structures. Starting top left, clockwise: historical background of region, different stakeholders debating on location, several functions of locations marked on map, additional issues marked with memos, navigation routes drawn on map, and final layout of one possible scenario

The coupled silt model for Lake Marken to study hydrodynamics, waves, and sediment in Lake Marken has been under development by Deltares since 2007. It takes into account wind-driven currents and waves to compute the amount of resuspension and sedimentation for a typical year. In this model, for wave effects a fetch length approach was used (Genseberger et al., 2011), the same approach is used in studies for other shallow lakes in the Netherlands (Penning et al., 2012).

The silt model only covers a part of the system that we need to address in the study. Figure 2 shows a schematic representation of the system with underlying physical, chemical, and biological processes and their interconnections. For the ecological expert judgement we interpreted results of the silt model and used in depth ecological expert knowledge of vegetation, fish, benthos, and birds from the recent so-called ANT study. In this ANT study long term trends and intercorrelations were analyzed for different species and their foodweb in the Lakes IJssel and Marken.

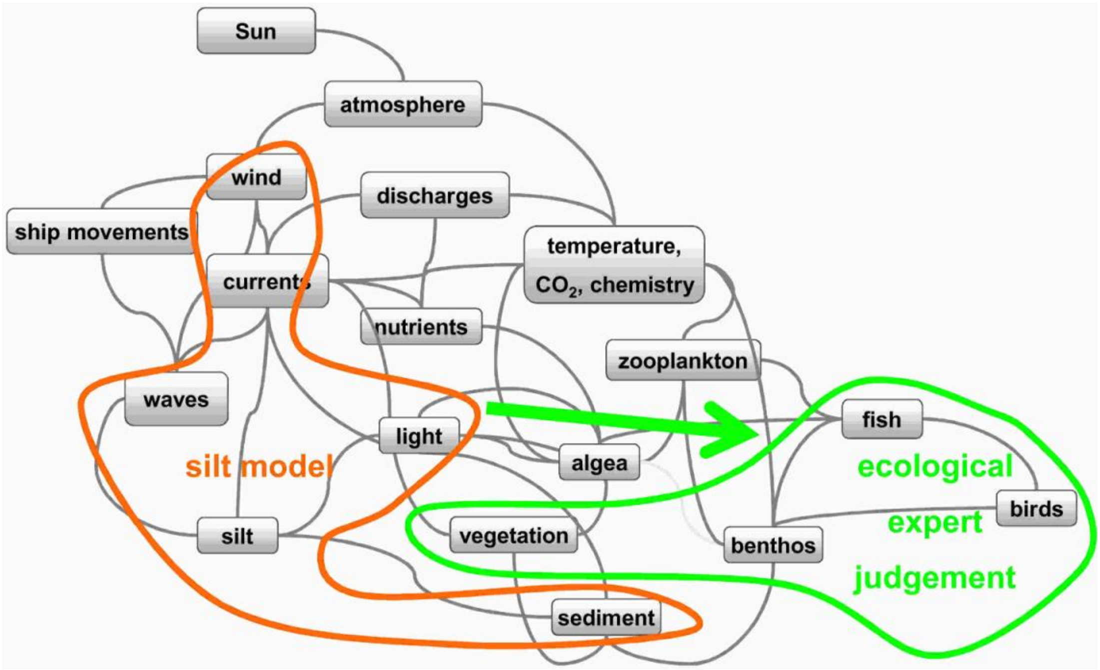

Fig. 2. Schematic representation of the system with underlying physical, chemical, and biological processes and their interconnections. The orange enclosure highlights the part that is modeled with the silt model of Lake Marken. The green enclosure is the part that is assessed by ecological expert judgement (based on results of the silt model and in depth knowledge of relevant processes and their interconnections)

Results

As mentioned before, at the start of the study, we defined the objectives of the study and the rules how to quantify the objectives. Effects on ecology were mainly estimated by modeling the changes in the amount of light on the bottom for each scenario. Important are the changes in the area where more than 2% and 10% of surface light reaches the bottom, representing potential habitat for low density vegetation and vegetation with sufficient density and structure to function as habitat for fish and invertebrates. Based on this, we combined and translated the results of the scenario analysis with the silt model, the ecological expert judgement and the interactive approach with different stakeholders into an evaluation that is usable for policy makers. As an example we show one of the tables that summarize this evaluation. Here table 1 shows the summary of the ecological effects of the three possible scenarios, the measure “Westcoast Dams”, the measure “Central Island”, and the measure “Eastern Archipel”.

Aspect	Criterium	Westcoast Dams	Central Island	Eastern Archipel
Waterplants and fish population	Expected development in sheltered areas	+	0/+	+
Protected areas	Goals to maintain under Natura 2000	+	0/+	++
	Effects on Ecological Main Structure	+	0	0
Protected species	Protected species	+	0/+	++

Table 1. Summary evaluation ecological effects of measures

Discussion

Here we showed how the combination of knowledge of the underlying physical and ecological processes and the interactive approach with stakeholders worked out during the study. For shallow lakes this type of multidisciplinary and practical study has not been done before on this large scale in the Netherlands. Therefore we think it is a significant case study.

The interactive approach with stakeholders in four working sessions was quite intensive. Also keeping this in phase with the assessment with silt model and ecological expert judgement may be further improved. However, the combination has shown its added value: in depth knowledge from experts was transferred to stakeholders during the working sessions, stakeholders came with creative and practical solutions, landscape architects were able to make designs with all ingredients available, and also policy makers were involved in all phases of the study.

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Water balance model for management and restoration of Te Waihora (Lake Ellesmere), New Zealand

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Keywords: water balance model, sea incursions

Introduction

Te Waihora (Lake Ellesmere) is a shallow lake located on the east coast of the South Island (Fig. 1). It is the fifth largest lake in New Zealand, and has a catchment area of 2072 km^2, comprising 777 km^2 from foothills and 1295 km^2 from plains.

Prior to human settlement the lake opened naturally when the beach barrier was breached at approximately 4.0 m above mean sea level (amsl) with a surface area of 315 km^2. After Maori settlement near Taumutu (Fig. 1), the village was subjected to flooding at high lake levels. Maori opened the lake when heights exceeded 2.7 m amsl. Currently the lake is opened at 1.13 m amsl between 16 June and 31 July and at 1.05 m amsl from August to March. Openings are made at lower lake levels in spring for fish recruitment and autumn for fish migration. At the mean lake level of 0.8 m amsl. the lake area is 189 km^2 and mean depth is 1.4 m.

Te Waihora is an internationally significant wetland for wildlife especially waterfowl and wading birds. This merited protection by a National Water Conservation Order (WCO) in 1990.

Recent amendments in 2011 to the WCO recognised four outstanding features: indigenous wetland vegetation, customary fisheries, Maori historical, spiritual and cultural characteristics, and significance in accordance with Maori customs and traditions, resulted in environmental openings replacing lake drainage openings.

The lake water has been enriched with agriculturally sourced nutrients and is turbid with high levels of re-suspended sediment from the lake bed. A water balance model has therefore been developed to assist with lake management and restoration (Horrell 1992 and 2009). This paper describes its application to Te Waihora.

Methods

The water balance model developed is specific to Te Waihora and covers its various inflows, outflows, and sea conditions, all of which affect lake openings, and resultant lake level fluctuations.

Figure 1: Location of Te Waihora (Lake Ellesmere) and photo of artificial opening.

The lake water balance equation is:

ΔS = (Ir + It + Ig + Irs + Ias +Is) – (Os + Oe + Oa)

where: I = inflows, O = outflows, ΔS = change in lake storage, with particular inflows Ir = rainfall, It = tributaries, Ig = groundwater seepage, Irs = rough weather sea incursions, Ias = artificial opening sea incursions and Is = Kaitorete Spit seepage, and particular outflows Os = Kaitorete Spit seepage, Oe = evaporation, Oa = artificial opening. These variables were estimated for a 42 year daily dataset, as follows.

Rainfall (Ir): Lake rainfall was estimated from 18 New Zealand Meteorological Service stations in the vicinity of the lake. The mean annual rainfall on the lake surface is approximately 564 mm.

Tributaries (It): Forty tributaries flow into Te Waihora, all except one being runoff from Banks Peninsula or emergent ground water. The exception is the Selwyn River sourced from the foothills. For 1970-86 tributary inflows were calculated from lake height rise, developed from available calm lake height readings and a lake area curve while accounting for known variables.

From June 1986 tributary flows were estimated using correlations with primary recorded tributary flow sites.

Groundwater seepage (Ig): Groundwater seepage through the bed of the lake was surveyed using seepage meters and estimated to be 0.44 $m^3 s^{-1}$ (Ettema and Moore 1995), an increase on a 1988 geological estimate of 0.08 $m^3 s^{-1}$.

Sea incursions: Sea water incursions into Te Waihora frequently occur across the low gravel barrier separating the lake from the sea near Taumutu. Sea water incursions occur in two situations: rough sea conditions (Irs), and those during artificial openings (Ias) when high tide encroaches into the lake, and later waves overtop the immature barrier.

Rough weather sea incursions (Irs): Flow rates are estimated by differencing all the known variables, and comparing with the inflows required to create the new calm lake levels. Records of sea wave conditions from the south show that sea inflows could occur when ocean waves are greater than 2.5 m in height.

Artificial opening sea incursions (Ias): Flow rates of 30.8 $m^3 s^{-1}$ for a period of 10 days were determined from openings using the methodology employed for rough weather sea incursions. Figure 1 displays an opening-reduced lake level at low tide with lake water outflow of 160 $m^3 s^{-1}$. Two hours later on the incoming tide 250 $m^3 s^{-1}$ of sea water was measured entering the lake.

Kaitorete Spit seepage (Os): A 3 km length of Kaitorete Spit near Taumutu forms a 150-200 m permeable gravel barrier between the lake and the sea. Estimates of seepage flow through this barrier from well measurements were analysed to derive a relationship between lake height and seepage rate.

Evaporation (Oe): Daily lake evaporation was derived from a Class A evaporation pan measured at Lincoln (9 km to the north of the lake) for the period 1970-91. After 1991 calculated Penman evaporation values were increased by a factor of 1.47 to replicate Class A pan. Open water daily lake evaporation estimates were derived using data from Lake Okeechobee in Florida (Hounam 1973), and adjusted for the Southern Hemisphere. Estimated average annual open water lake evaporation is 1075 mm.

Artificial opening outflows (Oa): On average the lake is artificially opened 3.6 times per year for a period of 17 days with an outflow rate of 75 $m^3 s^{-1}$.

Additional information

Wave conditions: Sea conditions directly influence the success of the lake opening operation and the lake closure. Model daily wave records were constructed from New Zealand Meteorological Service ship log wave information for 1970-91 with the remainder from a wave hindcast model (Gorman et al, 2003).

Lake opening: Rules for handling rough sea condition impacts on opening development were derived from comparison of nine artificial opening work logs with wave rider buoy information measured near the Rakaia River mouth and comparisons to ship log data.

Lake closure: Analysis of sea conditions required to close the lake provided rules for the model.

Lake area curve: A lake height - area curve was derived from a bathymetric survey combined with an adjacent land survey.

The model completes a water balance at day's end by calculating the total volume change divided by the lake area to produce the new lake level.

Results

Lake water balance

Variable water balance comparisons are possible from June 1986 when primary flow records and correlations with tributaries provided complete tributary inflows.

Lake variables	Flow	Percentage	Precision	Summer	Autumn	Winter	Spring
Period: 9 June 1986 to 31 December 2011	(m^3 s^{-1})	%	(m^3 s^{-1})	(m^3 s^{-1})	(m^3 s^{-1})	(m^3 s^{-1})	(m^3 s^{-1})
Rainfall inflows	3.49	18.5 +	± 0.30	3.04	3.48	4.23	3.20
Tributary inflows	10.8	57.4 +	± 1.23	6.82	7.15	15.69	13.16
Groundwater inflows	0.44	2.3 +	± 0.44 - 0.22	0.44	0.44	0.44	0.44
Rough weather sea incursion inflows	1.49	7.9 +	± 1.49 - 0.75	1.06	2.15	1.68	1.05
Artificial opening sea incursion inflows	2.59	13.8 +	± 0.78	0.82	0.47	4.32	4.55
Kaitorete spit seepage outflows	1.22	6.2 -	± 0.30	0.92	1.19	1.57	1.15
Evaporation outflows	6.68	34.2 -	± 1.20	12.40	4.71	1.94	7.81
Artificial opening outflows	11.64	59.6 -	± 1.16	3.95	4.16	21.40	16.16
Storage change	0.01	0.5 -					

Table 1: Te Waihora (Lake Ellesmere) annual average water balance and seasonal variability

The change in storage is considered almost insignificant with a net loss in storage equivalent to 0.01 m^3 s^{-1}. The total outflows (19.54 m^3 s^{-1}) are greater than the total inflows (18.81 m^3 s^{-1}) by 0.72 m^3 s^{-1} after consideration for storage change.

Model performance

For 1970-2011, the number of modelled openings was 152 compared with 147 actual openings. This 3.4 % difference is considered a close reproduction of what happened to the lake and the magnitude of the lake variables (inputs and outputs). The probable reasons for the different opening numbers and timing are: using averaged rates of outflow and artificial sea incursions inflows, which in reality varied with each opening. Also, modelled sea condition records may predict different opening dates, while some of the variable inflows or outflows may be uncertain.

Figure 2 displays a regulating effect of evaporation upon actual and modelled summer lake level in January 1979, which resulted in the first modelled winter opening being close to date of the actual opening.

Discussion

The model was developed to study lake management options using 42 years of daily data. Scenarios examined included varying opening levels, opening seasons, closing levels, input and output volumes, lake area, and a permanent opening. The key model outputs for lake managers are: new lake level regime; number of openings; timing of openings.

Uses of the model include: specifying the opening level regime recommended in the Draft WCO (adopted 1990); modelling proposed irrigation bywash from 60,000 hectares for the Central Plans Irrigation Scheme (upstream of the lake); developing key Environment Court evidence in 2011 for amendments to the 1990 WCO from testing scenarios to improve the frequency of environmental autumn and spring lake openings; modelling consenting processes to artificially open the lake for Canterbury Regional Council to manage the lake optimally with regard to ecological values; and supporting lake resuscitation research into alternative opening location and weir to avoid low lake levels and reduce salinity.

Key knowledge advances from the water balance modelling include: the avoidance of shoreline desiccation from prolonged summer and autumn low lake levels, 70% enhancement of environmental openings to improve fish recruitment in spring and fish migration in autumn, how to achieve fewer artificial openings, how to reduce salt concentrations, an explanation on how the Trophic Level Index may be reduced from 7.5 to 6, and seasonal variation of lake variables.

Other uses of the model include studies into: fish habitat and recruitment, wetland habitat, salt marsh communities, macrophyte re-establishment, discolouration, and flooding risk to agricultural production in reclaimed areas.

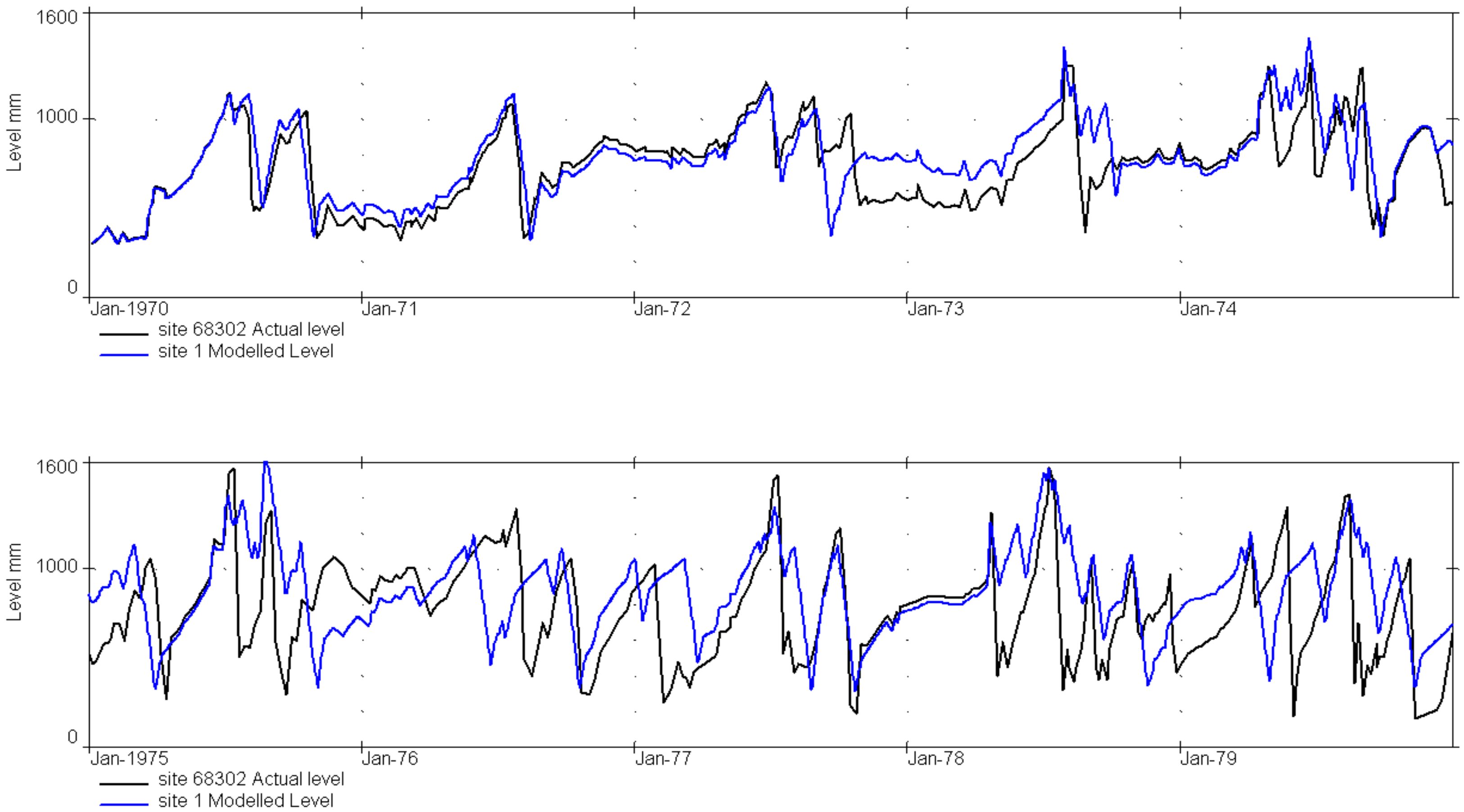

Fig. 2. Comparison between actual and modelled lake level and openings (the sharp level decreases) from 1970 to 1980: Te Waihora

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Non-Point Pollution and Erosion int the Lake Chapala Basin, Mexico

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Keywords: Lake Chapala, non-point pollution, siltation, Multistakeholder Platform

Introduction

Lake Chapala is Mexico's largest water body, an ecosystem of high priority due to the set of environmental services it provides, including biodiversity, weather regulation, fisheries and water for irrigation, industry and human consumption. Lake Chapala has a surface of 1112 km², it forms part of the Lerma-Chapala basin, which covers 52 532 km² and is composed of 19 sub-basins. Back in 2009 a dyagnosis of scientific research was prepared, which showed the huge amount of lacking data related to the lake and its basin. Derived from it, a two-years project was conducted, concentrating in the lake itself and the sub-basin that drains directly into the waterbody (Lake Chapala basin). The project focused into knowing the volumes, types and source areas of agrochemicals and soil loss, thus generating a series of complementary management tools (GIS, SWAT and a Multistakeholder Platform).

Materials and methods

There were used several methods for each aspect of the research. For erosion measurement there were used 20 run-off plots (monitoring stations) allocated in agricultural areas, divided into three categories: a) irrigated cultivation, b) rainfed cultivation, c) hillside cultivation. Additionally, another 20 run-off plots were installed in forest covered areas. Three sediment collections were accomplished during 2011 rainy season.

Use of agrochemicals (fertilizers and pesticides) was determined using a survey, applied to 368 farmers. Farmers were organized into three groups, matching the categories of cultivation. The survey also collected information about the productive process (land extension and ownership, technology, volume of production) and farmers' social features (number of family members, education level, monthly income, etc).

To determine water quality, there were stablished 20 sampling points at Lake Chapala in-flow points, to measure AGP (Algal Growth Potential) and nutrients presence, which were sampled during three campaigns: rainy season, dry season and stabilization season (2011-2012).

A GIS system was constructed using contents from municipal, state and federal agencies, complemented with satellite images. As part of the process, a basemap was developed alongside with a digital elevation model. Several thematic maps were created, some requiring infrared analysis using a especial software (Explorafor). As for the Soil and Water Assesment Tool (SWAT, a model to predict quality and quantity of surface and ground water, and to predict the impact of land use), the one created for this project used as inputs the GIS system, climatic data series from 1940-2005 (ERIC III, version 2.0) and Mexico Metereological Stations. For nutrients and agrochemicals there was used the farmers survey; for water erosion it was used the data generated by the run-off plots and for the nutrients in water it was used the information from water sampling points.

Finally, for the Multistakeholder Platform (MSP) it was used as reference the model set out by Faysse and Vladimir (2005), complemented with the one used previously in the Lerma-Chapala basin by Juarez and Enriquez (2012). To create the MSP it was necessary to construct a Conflict-Collaboration Matrix (modified from Grimble, et al., 2005) to show up the conflic conditions between stakeholders, related to ther main components of the project.

Results

Natural vegetation areas in the Lake Chapala basin contributed only with 2.5% of total soil loss by rain erosion, while cultivated areas produced 97.5% of it. From this quantity, close to 45% soil loss is generated in hillside crops, which represent only 7.17% of the total cultivated area. Hillside areas are used by the poorest farmers, which also use the highest amount of agrochemicals per hectare, due to the fast loss of fertile soil and the consequent lack of nutrients.

As a whole, the three groups of farmers use more than 25000 tons/year of fertilizers, generating a load of nutrients than enter constantly into the lake, they also use more than 340 tons/year of pesticides in the direct vicinity of Lake Chapala, including 22 classified as “extremely toxic” for plankton, fishes and birds (INE, 2012).

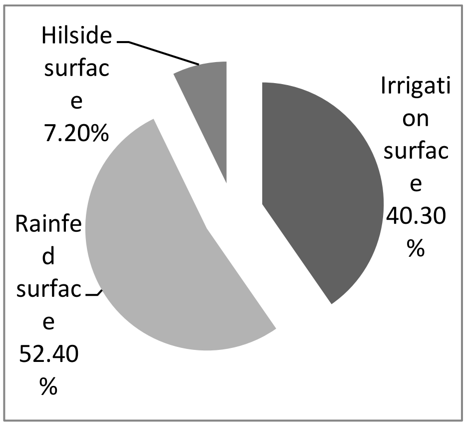

Fig. 1. Categories of cultivated land in the Lake Chapala basin

2011 was a year of scarce rain. However, during its rainy season there was a loss of 102,652 tons of soil coming from cultivated areas. The SWAT model predicts that during strong rainy seasons such amount could increase up to 415% There was found that just a small portion of farmers use soil conservation practices, mostly because loss of knowledge, given the fact that such practices were widely used until 1970-1980.

Water monitoring sites that received mixed (urban-industrial) non-point pollutions showed during the dry season the greatest potential to promote algal growth. The rain dilution effect was unremarkable in September and most notorious in January. Agricultural and livestock sources showed higher fertility amounts in the rainy season due to increased runoff, almost zero during the dry season. Contributions of productivity stimulants studied from the analyzed sources are considerable, the biota of the receiving water body (Lake Chapala), seems to serve as processor of nutrients. Consistent with previous fertility patterns studies (Hernández et al., 2001), sites that had the highest water fertility were mostly limited by nitrogen, those sites with lowest water fertility were limited by both N and P (co-limitation).

In the case of the GIS, its final version included 24 layers, with several thematic maps, being the one of Current Land Use the most useful for its level of accuracy, showing the allocation of hillside cultivation areas. Also, it was important the updating of the Lake Chapala perimeter, using remote sensing methods.

The SWAT agrochemicals future scenario shows them spreading throughout the basin. A direct consequence is the possibility of increasing eutrophication in Lake Chapala and its affluents. Pesticides also follow a similar trend, with risks of affecting terrestrial and aquatic organisms, as some of them (such as methyl parathion) have high toxicity levels.

Finally, the MSP shows that farmers are not the only stakeholders related to analysed issues: 53 different groups and institutions were identified, organized in five sectors (productive groups, research institutions, government agencies, councils/commisions and NGOs). Even having influence in the basin, 67% of stakeholders have no physical presence in the area, which don't stop them to define projects, and regulations. All groups had a wide perception that agrochemicals didn't represent a pollution source and therefore it wasn't necessary to regulate their use. Nevertheless, when informed about the findings of this project, several farmer groups expressed strong concern about it. Working with them, it was clear that an indirect approach could be more effective, using three arguments: a) improving economic benefits for farmers, b) protection of human health, and c) reducing of poverty. Using this structure, two particular MSP were defined, one for reduction of rain erosion and other one for agrochemical control. Both MSP were defined for a three-year period, working in three different areas of the basin, taking into account the cultural and organizative particularities found during the research.

Some Lines of Action must be taken to control the excessive use of agrochemicals, being these a) inform broadly to the government sector about the agrochemical types and volumes found in the area and their possible effects, b) to use the knowledge and attitudes of organic farmers to promote involvement of other agricultural groups, c) involve environmental NGOs and resarch institutions in the process to avoid social polarization and the emergence of conflicts.

This project is one of a few that pay attention to the non-point pollution issue and its effects on Mexican lakes. Our findings shows that there is a poor understanding of the problem, therefore there aren't regulations nor management policies. We expect that this information could be used as a first step to improve the current situation, not only of Lake Chapala but also of other water bodies in Mexico.

Acknowledgements

To the National Council of Science and Technology (CONACYT-Mexico), FIDERCO and the Government of Jalisco State, for their financial and institutional support. To Masahisa Nakamura and Walter Rast (ILEC) for their constant presence and advisement.

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Water Sensitive Urban Design, WSUD

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Keywords: WSUD water sensitive urban design, phytoremediation, constructed wetlands, urban aesthetics, urban catchment

Introduction

The paper draws the attention to the need of spreading the concept of WSUD Water Sensitive Urban Design applied to urban lakes safeguard, merging urban/territorial planning and landscaping with sanitary engineering and using the urban catchment as a reserve of additional water source. WSUD tries to blend the use of urban aesthetics and urban park with the use of species able to act as biological treatments for runoff waters in constructed wetlands: a sort of Phytodepuration Park, to reduce water pollutants in the urban drainages, opening the door to a systematic urban catchment water reuse.

WSUD

The paper's objective is to show systems combining urban landscape design and biological treatments for the reduction of pollutants coming from the urban open spaces and agricultural activities in the periurban areas, using solutions such as ecotone strips, filter ecosystems and artificial wetlands. The ecotone strips refers to the transition area between two ecosystems (Odum 1982), such as the transition area between land and water environments. It may be a strip of riparian vegetation with a woody or rushy character, or a meadow or forest separating farmlands from reservoirs or watercourses. Ecotones, as barriers limiting the flow of chemical compounds from the land into lakes or rivers, are referred to as buffer strips (Vought et al. 1994). Specific types of buffers include riparian vegetated buffer strips, vegetated filter strips, protective zones, biogeochemical barriers, shelter beds, and hyperrheic zones. The hyporheic zone is a region beneath and alongside a stream bed, where there is mixing of shallow groundwater and surface water.

The paper intends to draw the attention to a sort of wide-scale urban environmental restoration programme for the urban water quality and urban catchments, and considers of paramount interest to stress the need of introducing the concepts of water sensitive urban design in Europe especially regarding urban lakes as constant safeguard measure; moreover it draws the attention to the need of realizing WSUD projects and to boost the WSUD methodologies and research, that unites a wide range of professionals and forms a new multidisciplinary sphere of action to protect urban lakes and internal waterways, thus pushing to the introduction of a new set of infrastructures and products to realize WSUD also in our latitudes with the winter climate constraints and using local species.

This presentation objective is to give a contribution to foster the stakeholders to harmonize urban planning with the related hydraulic structures and agricultural best practices to make possible a new urban runoff re-use policy. Moreover there is the need on one side to consider

the urban catchment as a new source of water for urban uses and from the other side it is necessary to envisage a new set of hydraulic infrastructures construction around the urban lakes meant to intersect polluted runoff from the catchment to safeguard lake waters quality.
The paper provides considerations on stormwater management with an added insight into incorporating WSUD into a highly functional and well integrated public open space design.
Urban sprawl and WSUD are linked together because from the spontaneous growth of the towns near lakes and internal waterways derives the need for a urban design sensitive towards the preservation of the water resources.
Another issue included in WSUD are the social, environmental and economic values that are associated with urban lakes. Urban lakes interact with the surrounding environment, and there is need to identifying and prioritizing lake management issues and values over sectarian interests. Strategies Guidelines to help determine appropriate management and rectification responses are needed. A fine combination of both the WSUD and traditional conveyance with considerations of storm water management, are necessary for a well integrated use of public open spaces. To this aim we have set up the WSUD Association Italy Onlus, with the mission of serving the community of those involved in the WSUD, promoting the development of the culture of creating communities committed at various levels to the sensitive use of water resources; and with the purpose of international leadership in WSUD throughout all its activities.

Case Studies

The selected case studies refer to two on going activities in the Lazio Region, following two co-financed projects: a Filas Co-research and a Life Project.
A first example is the proposed treatment of the superficial water runoff into the lake of Vico; a study proposed as mitigation measure within the co-research project between Alpha Consult and five Research Institutes: DIAP Department, University of Rome "Sapienza", DAFNE Department, University of Viterbo, the Italian Geographical Society, the National Research Unit for Climatology and Meteorology applied to agriculture and the National Research Centre for the Study of the Relationships between Plant and Soil.

Fig. 1 Vico Lake

Lake Vico offers a very interesting example within the Latium volcanic lakes studied, because the pollutant load to Lake Vico is much more vulnerable than those of Bracciano and Bolsena and whatever rains in the basin goes to the lake and there is only a small outflow of very superficial waters. In fact the specificity of the place makes the untarred rural roads becoming rivers in case of rain, impossible for tourist purposes and dangerous to the runoff of nutrients into the lake. The local situation often shows areas of degradation where there is need to recover the degradation by arranging open spaces and constructed wetlands. Hazelnut trees are present in the area surrounding the lake and the fertilization processes increase the lakes water nutrients accumulating them in the deeper water layers. The runoff analysis into the lake of Vico was the first activity of the project, providing the water quality input values. DAFNE, carried out surveys, to define the location of the places where to harvest the water running along the slope and into the lake and locate lateral reconstructed wetland on course of affluent streams incoming paths to allow the creation of recreational tourist points with water quality functional control to fight water eutrophication and helping in the soil erosion control.

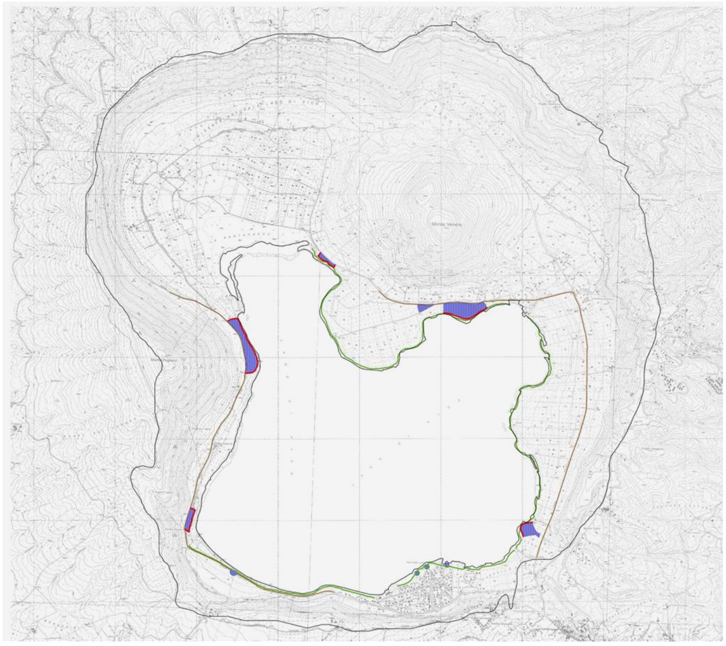

Fig. 2. Drainage collection trunk line around the lake and areas where phytodepuration spots can be located

The project aims also at tourism activities encouragement a sort of *"paths of water: from Van Wittel to the present days".* The main project tasks are Lake environmental regeneration by means of a drainage collection trunk line going around the shore, areas of phytodepuration spots organized as tourist view points and park areas connected to Rio Vicano paths, emissary of Vico Lake; more information available at www.alphaconsult.it/pst.

A WSUD for Mastro Pietro Park

The second case of studies refers to Mastro Pietro channel in the Pontina Plan with the implementation of an experimental system for phytoremediation in the municipality of Latina in the Marina area. The WSUD project envisaged a linear park in the area with the realization of an experimental plant of over 4300 square meters of phytodepuration, consisting of several basins for water purification. The concept idea is to exploit the different elevation of the to drainage channels and outflow part of the waters from Mastro Pietro channel and after the phytodepuration process the purified waters are entered in the Colmata channel. The preliminary design and survey started in 2010-2011, with Alpha Consult srl collaboration with Professor Ezio Ranieri, Bari University, under Life Rewetland Project involving both the local Government and the Province of Latina. Works are now almost completed. The project is an example of a widespread introduction of constructed wetlands for a wastewater treatment of Agro Pontino internal waterways/channels using WSUD principles.

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Volcanic lake basins integrated framework for landscape functionality assessment

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Keywords: lake basins, landscape functionality assessment, GIS technology, water management tools

Introduction

A co-research project for the Lazio Region is undergoing, financed by European Community through Filas S.P.A., with the coordination of Alpha Consult in cooperation with five research institute namely: Sapienza University of Rome DIAP Department, University of Tuscia - DAFNE Department, Italian Geographical Society, CRA-CMA National Research Unit for Climatology and Meteorology applied to agriculture and CRA-RPS National Research Centre for the Study of the Relationships between Plant and Soil.

The project analyses the environmental systems linked to the five volcanic lakes of the Lazio Region that represent sensitive case studies to anthropic transformations. The paper will explain the type of data needed to run the GLEAMS Model, Groundwater Leaching Effects of Agricultural Management Systems, and how they were structured on the GIS and thereafter in the simulation Portal with the presentation of the main used themes and the new developed tools.

Materials and methods

The project takes into account the methodology to evaluate the functionality of lakes' landscape in ecological terms and socio-economical uses.

The ecological terms concern in verifying nutrient cycling, water purification gained by changing land use, biodiversity instead socio-economical uses refer to recreational and aesthetic features of the landscape to encourage local economic for instance horse trails, fishing and agricultural production.

The aim of the project is to set up an integrated framework for landscape functionality assessment in land use planning for the management of urban and agricultural planning in the Lazio Region volcanic lakes hydrological basins and realize a web service based to allow the planner to use environmental modeling to study the impacts of land uses on the project area. In particular, the system analyzes and simulates the impact of diffuse sources of pollution (mainly nitrogen and phosphorus) on surface water bodies of the Lazio Region, in particular on the crater lakes of Bolsena, Vico, Bracciano, Albano and Nemi.

One central aspect of the project is to create a web portal to communicate the results of the researches. The portal collates the works carried out by Alpha Consult to set up the Web GIS for the publishing of data produced by the Research Institutes for the project PST-CSA territorial strategic planning for proper environmental sustainability.

Results

The GIS and WEB GIS tools implemented makes it possible for local technician to provide assistance to politicians to understand what are the priority choices to be made and to provide an aid to negotiation with local stakeholders (farmers, tourist offices, active citizens groups and associations).

The new features developed specifically for the portal allow to perform simulations on the network. These simulations are designed to aid the planner to create different planning scenarios and to show the changes that planning involves in the water quality of the lakes.

The functions allow to make on-line, on the network, activities that a GIS system allows locally on personal computers and benchmarks can be continuously updated in real time. In this way it is allowed to share simulations between multiple stake holders and it is possible to see what effect the choices made could create.

The display update is automatic and allows to extract different data scenarios, which are essential for the planner. According to Professor Bernardo Secchi: "The definition of scenarios in recent years seems to have become an essential component of the decisions on the transformation processes of the city and the territory. The fast change and the multiplicity of actors involved need to project the hypothesis of the project within the future to assess the likely impacts, reliability, sharing" (Secchi, 2000).

The proposed methodology and the online geographic information system (GIS &WEBGIS) will allow all governments of the region to carry out simulations of a change of scenario for changes in land use and its impact on the state of water resources. Such a cognitive tool to support the decision-maker might affect in a decisive way in the early stages decision with respect to spatial planning, where now the parameters to keep in mind and the data to take into account apply to a plurality of issues to be addressed simultaneously that are outside the range of a single expert.

Discussion

The first **step** in building a web environment for communicating research results has been collecting PST Project data highlights that were organized in GIS and poured in the Portal.

After collecting suitable data worthy of mention is the effort of having overlaid in the same projection, maps derived from different sources with the difficulties of changing map projection to the data sets that have been placed together in a continuum space, which provides the user with a territorial container that specializes at every scale by showing the data to the most appropriate scale and with the necessary details to the actual scale of consultation. Display design is complemented by the graphic design that automatically allows the user to turn on or turn off data more suitable to be displayed to the particular scale.

A special attention has been dedicated to transpose the vector data of the different theme in polygonal topologies ready to be not only overlapped but merged together to form a single information layer (the so-called overlay) on which to apply the modeling (Figure 1). The overlay have merged together layers of: Rain data, Watershed map, Land use map and Slopes map.

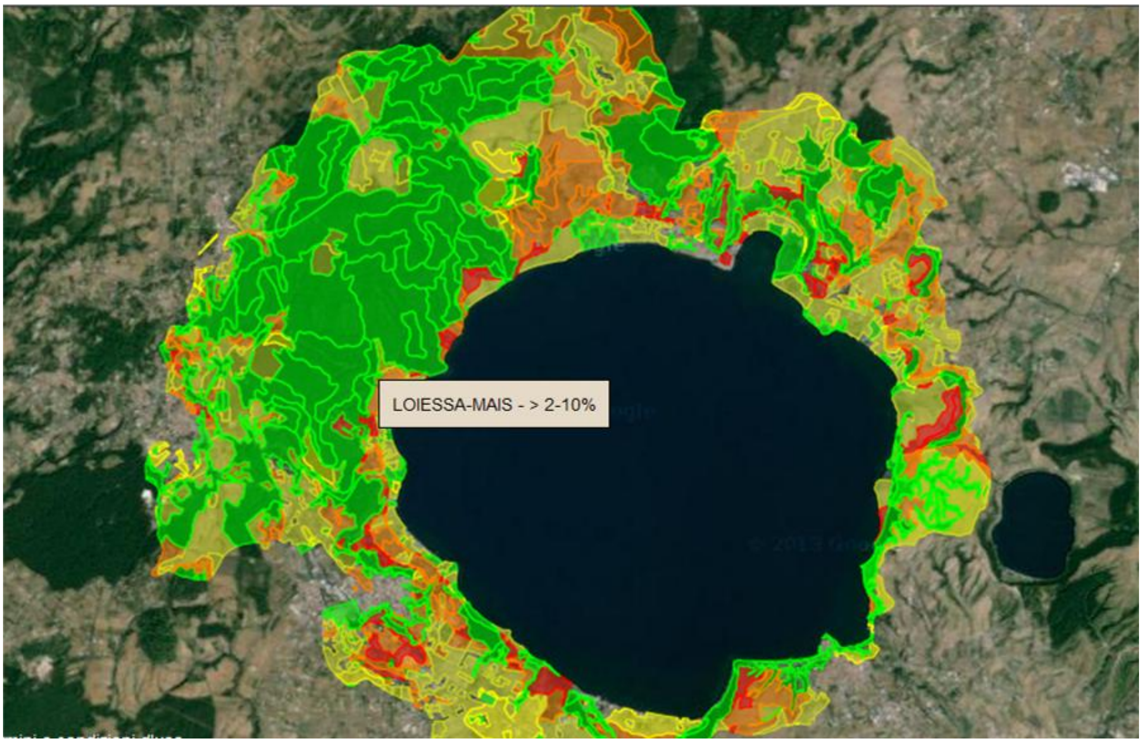

Fig. 1. The result of the overlay between soil use, slope, basin, rain data

In this way one polygon has only one value in each of the different theme. The polygon obtained by the intersection of the basic themes is so connected to a single record of the database storing the result of the model.
Extending GIS technology on the internet is a powerful tool for the dissemination of data and for the sharing of related information available to multiple users simultaneously. In the realization of the project on this platform have been developed accessory functions in order to ensure that in addition to classic queries connected to the polygons on the GIS (to select, view and edit values) the user could also operate to repeat the simulations made by the GLEAMS model highlighting the results on the cartography.
To make interactive simulations the selections made on the online mapping needed to be managed by a number of suitable features that produced the end result. The result is obtained as a given polygon, and as an aggregate of all the polygons in the river basin whereas taken together, provide the environmental quality of the lake.
The main difficulty has been to ensure that the user could perform a interactively simulation changing online the land use value to view the results in the lakes health layers with the updated related values.

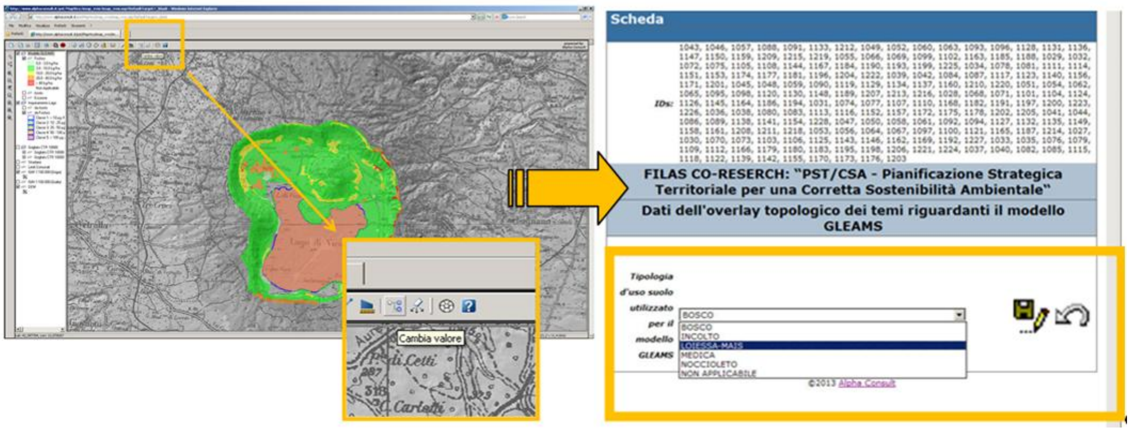

Fig. 2. The GIS Portal, provided with functions that allow to visualize the results on the lake water nutrient content simulating changes in the land use

The user may decide to change directly on the fly the land use type of one/more polygons, by acting on the overlay theme value. The system/geodatabase identifies the selected polygons and change the value of contributions of environmental modeling parameters such as phosphorus or nitrogen.

These simulations are driven and based on predefined scenarios stored in the database, that can be improved, and allow to change the value of a theme and see what happens in the other topic: in this way changing the land use will produce the result of getting the result for pollution in the lake. That is not only to enable queries to the database but to be interactive in the use of GLEAMS model data, all without leaving the Web GIS cartographic consultation.

Thus, the portal gives access to structured data that have been placed on the Web Server and the interaction on the Web GIS determines the possibility of multiple users on a network to work on a common territorial board and simulate scenarios placed at the disposal of all.

The University of Tuscia work produced GLEAMS model processing data that have been conferred to the on-line DBMS. In order to accommodate the modeling data it was necessary to perform GIS basic themes intersection (topological overlay) and then producing output tables in the geodatabase describing overall polygons overlay data. The polygons of the overlay have been connected to data from the GLEAMS model processed in the SQL database merging geographic information and model results, available for the online mapping simulation.

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Urban lake management strategy: effect of distinct types of lake surroundings and shoreline landscape development on water quality of urban lakes in Megacity Jakarta

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Keywords: urban lakes, water quality, management strategy, megacity

Introduction

Rapid urbanization has greatly impacted on the degradation of water resources. Urban lakes in megacity Jakarta have suffered from water pollution due to point and non-point sources originated from surface run off and discharge of untreated domestic and industrial waste waters. One of the most serious problems of water pollution is eutrophication due to nutrient overloading especially phosphorus where the lakes experience the excessive algal blooming including nuisance toxic cyanobacteria of microcystis and even invasive floating and submerged aquatic macrophytes (Birch and McCaskie, 1999; Priadie, 2011, Prihantini et al 2008; Sulawesty et al, 2012). Urban lakes tend to become more eutrophic and greener than non-urban lakes (Schueler and Simpson, 2001; Naselli-Flores, 2008). The eutrophication problem has caused lake reducing its carrying capacity and losing its ecosystem service such as water supply, recreation, fishing or some other direct human use. This paper is aimed to examine the water quality especially association with eutrophication problem in several urban lakes in megacity Jakarta according to the types of lake surroundings and shoreline development and to propose possible management strategy.

Materials and methods

This study examines what important indicators related to distinct types of lake surroundings and shoreline landscape development affect an urban lake water quality in relation to nutrient and organic pollution. The urban lakes examined are in the area of megacity Jakarta which is basically the capital city of Jakarta and surrounding regions (Fig. 1). The types of lake surroundings identified according to the criteria from the previous study (Henny and Meutia, 2014). We examined the water quality of 9 urban lakes in megacity Jakarta with distinct types of lake surroundings based on the types of inhabitants around the lake's buffer zone area such as urban village (dense irregular housing), rural village (agricultural area and few residential housing); rural-urban village (mixed rural and urban village); sub-urban village (mixed planned residential and irregular housing with less green area) and urban-industrial area (mixed urban village and industrial area). Shoreline landscape development in lakes includes natural shoreline (with more green open space), natural-artificial shoreline (lack of green open space with concrete jogging tract) and artificial shoreline (no or less vegetated cover, concrete retaining wall and jogging track). Physical and chemical parameters measurements included temperature, pH, turbidity, conductivity, salinity, Dissolved Oxygen (DO), total dissolved solids (TDS) and secchi depth (SD). The measurements and the water sampling were done in March and May 2014. The measurements were conducted by using the Water Quality Checker (WQC, Horiba U). Lake water was sampled at several sites of lakes for lab measurements such as Chemical Oxygen Demand (COD) as organic material parameter, nutrient (total nitrogen (TN) and phosphorus (TP)) and chlorophyll-a concentrations. The analyses of COD, TN and TP were done by using HACH method procedure (HACH, 2005). Chlorophyll-a was measured by using a spectrophotometer (HITACHI) according to the standard method procedure (APHA, 2005). Trophic state index (TSI) also was calculated to classify the trophic status of the lakes by using equation from Carlson and Simpson (1996).

Results

Lakes in rural village with natural shoreline and various types of vegetation in lake's buffer zone are still well maintained indicated by the presence of submerged aquatic and emergent plants in lake littoral area. Spotted several types of dragonflies and butterflies suggest that ecologically the lake's condition is well preserved. The lakes contain less nutrient (as TN, TP), chlorophyll-a, organic matter as COD concentrations and less turbid water indicated by higher water transparancy mesurements of secchi depth (Table 1). On the other hand, lakes in sub-urban, industrial and urban village with more artificial shoreline development have quite high concentrations of nutrient, chlorophyll-a and organic matter in its water (Table 1). Based on trophic state index (TSI) calculation by Carlson and Simpson (1996) on the concentrations of chlorophyll-a, TP, TN and secchi depth, the lakes were classified from mesotrophic to eutrophic (Fig. 2). The results indicate that the value of TN:TP ratio of 20 is the borderline condition for meso and eutrophic conditions (Fig. 2). Higher values of TSI (P) indicated that phosphorus was a major factor causing the eutrophiction by algal bloom in the studied urban lakes. Two lakes (Gintung and Rawa Besar) in urban village area were considered hypereutrophic with indication of blooming of toxic cynobacteria of microcystis.

Discussion

Eutrophication problem have been one of challenging problems in most of urban lake in megacity Jakarta. High nutrient pollution from N and P loadings have been causing severe eutophication problem in most of lakes especially shallow urban lakes which indicated by dark green water color as a sign of green algae blooms and sometimes with excessive macrophyte coverage on the water surface. Several lakes with surroundings type of urban village and agricultural area in megacity Jakarta has been reported to have problem with cyanobacteria contamination and invasive floating macrophyte coverage from the type of *Eichornia sp.* (Priadie, 2011; Prihantini et al, 2008; Kristiana, 2003; Sulawesty et al, 2012). However, the lakes in rural area with more natural shoreline development show better water quality. Previous study on several shallow lakes in rural area and natural shorelines also indicates lower TN, TP and chlorophyll-a concentrations, while the lakes in agricultural area contain higher TN, TP and chlorophyll-a concentrations (Sulastri, et al., 2008). The lakes which its littoral area covered with submerged and emergent aquatic plants have better water quality with less turbid water, low nutrient, chlorophyll-a and organic mater concentrations than the lakes that are no indication of submerged and emergent aquatic plants presence in its liitoral area. The presence both controlled submerged and emergent aquatic plants in lake's littoral area apparently can improve lake's water quality. The results suggest that phosphorus is apparently a major factor causing the eutrophiction by algal bloom in the studied urban lakes and therefore the reduction of nutrient especially phosphorus loadings should be one of management strategies to maintain better lake water quality. In addition, the submerged and emergent aquatic plants should be restored and controlled in littoral area to improve ecological condiditons of the lakes.

Lake	Surroundings Type	Shoreline Development	TN mg/L	TP mg/L	Klorofil-a mg/m3	COD mg/L
Tonjong	Rural Village	Natural-Artificial	1.086 - 2.684	0.014 - 0.309	0.719	82.26
Dora	Agricultural Area	Natural-Artificial	0.610	0.014	2.648	43.548
Cibuntu	Rural-Urban Village	Natural-Artificial	0.763	0.026	5.472	35.484
Kemuning	Rural Village	Natural	1.232	0.026	1.477	80.645
Cikaret	Rural Village	Natural	1.757 - 3.029	0.037 - 0.074	1.867	98.387
Babakan	Sub-Urban Village	Artificial	1.161 - 3.100	0.031 - 0.315	5.585	172.581
Gintung	Industrial-Urban Village	Natural-Artificial	1.778 - 3.384	0.117 - 0.331	46.650	141.935
Rawa Besar	Sub-Urban Village	Natural- Artificial	2.065 - 2.069	0.187 - 0.318	43.734	169.355
Rawa Kalong	Urban Village	Artificial	1.538	0.379	35.774	72.581

Table 1. Nutrient, chlorophyll-a and COD concentrations in urban lakes

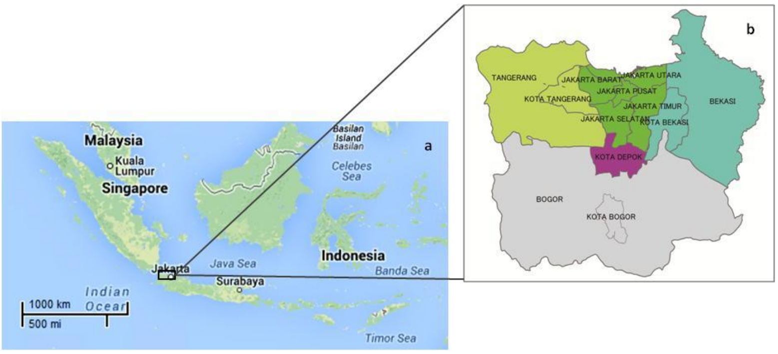

Fig. 1. Location of megacity Jakarta (a: Indonesian map by Google Map, 2103 and b: the regions composed of Megacity Jakarta by Mimura (RIHN Researcher, 2013)

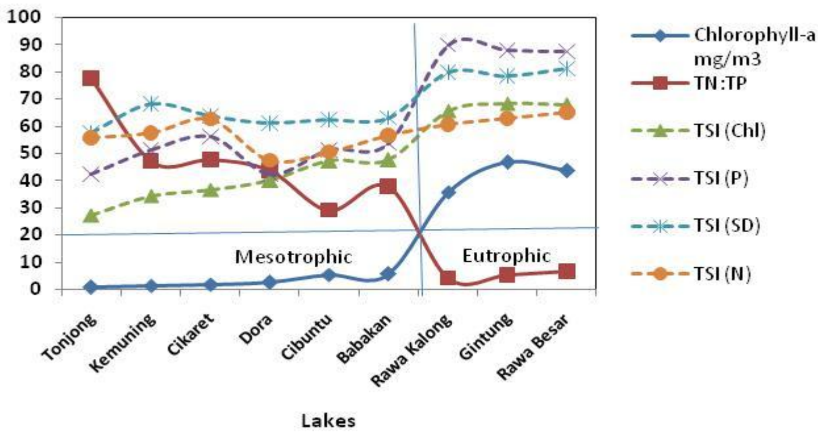

Fig. 2. Trends of TSI in association with TN:TP ratio and chlorophyll-a concentration

Distinct lake surroundings and shoreline development are indeed to have an impact on urban lake water quality especially associated with the eutrophication problem. Reducing the phosphorus loadings to the lakes by managing nutrient input to the lake, setting the lake shoreline with more natural and more green open space, restoring the submerged macrophyte and maintaining emergent plant in the lake littoral area can be good management strategy to reduce the eutrophication problem in urban lakes in megacity Jakarta and to preserve a long-term stability for good lake water quality.

Acknowledgements

The research is funded by Toyota Foundation, Japan. The author thanks Y. Mimura to have provided with the map of megacity Jakarta. Special thanks to Ira Akhdiana S.Si., to have helped with lake sampling.

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Coliform and *E. coli* levels at several urban lakes in Jakarta Megacity

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Keywords: Urban lake, Jakarta, megacity, total coliform, *E. coli*

Introduction

Urban lakes, natural or man-made lakes (situ/waduk in Indonesian) in Jakarta Megacity (Jabodetabek) have played an important role for irrigation, flood control and groundwater storage for a long time. Many of man-made lakes were believed to be built during Dutch colonial. For decades, these urban lakes suffered from unplanned rapid development, urbanization and illegal occupancy. Hence, the actual function of the urban lakes has not been activated in the optimum condition. Moreover, because of the government's neglect and the low awareness of public, almost all of urban lakes have been polluted and filled with untreated sewage and solid waste. As a result, the urban lakes became breeding grounds of pathogenic bacteria, especially the one that causes waterborne gastroenteritis.

Waterborne diseases can occur when a human-being ingest or gets in touch with water that contains pathogenic organisms. Pathogens can enter into water supplies from human and animal wastes. Gastroenteritis caused by waterborne disease is very common in Indonesia due to ineffective public health controls and poor hygiene standards. About 1.7 to 5 billion cases of diarrhea occur every year (WHO, 2013). The morbidity and mortality of the disease are much higher among childeren and older people. Situation is deteriorated when the amount of bacteria is diffused by the flood that hits megacity Jakarta every year and elevates the risk of waterborne gastroenteritis.

Flood disaster is the most common (40%) natural disasters worldwide and is strongly related to the change of weather and climate (Howard et. al., 1996). Megacity Jakarta's predictable, but hazardous annual floods inundate the cities every rainy season from December to February, engulfing tens of kilometers of residential city areas with up to four meters of sewage-infused floodwater for days (Sakethi, 2010). Post-flood disease is one of the most serious problems among the increasing incidences which come after flooding. Many diseases out-break because water sources are contaminated with fecal material and toxic chemicals. The flood water mixed with pathogenic bacteria in urban lake can spur diseases, including diarrhea such as the case in 2007. Moreover, people around the lake are fond of fishing and eat fish from these urban lakes.

These facts show the importance to study about environmental health of urban lake relating to the floods and urban ecosystem in Jakarta megacity by using indicator of total coliform and E.coli bacteria.

Materials and methods

The examined urban lakes were within 8 types of the urban ecosystems as described by Henny and Meutia (2014). These types were developed from 4 type urban ecosystem described by Hayashi (2013). We use data taken by BPLHD DKI Jakarta for coliform bacteria and *E. coli* for urban lake in DKI Jakarta from 2009 to 2011. The method was Indonesian National Standard (SNI), SNI 06-4158-1996 for coliform count and SNI 19-3957-1995 for *E. coli* count. As water qualities data from Jakarta Megacity's urban lakes were quite rare, for other urban lakes surrounding DKI Jakarta, we measured the total coliform and E. coli using Standard Methods. The sample was duplicated and taken from inlet, middle and outlet of the urban lakes during the rainy and dry season. Then, the data was plotted to the Map by using GIS.

Results

To compare with the 8 types of urban ecosystem in DKI Jakarta, the urban lakes located in 6 types of urban ecosystem have extremely high level of total coliform and *E. coli*. Meanwhile, the urban lakes which located in Planned Residential Area and Rural-Urban (Ruban) Village Area such as Rawa Dongkal, Babakan, Sunter Hulu and Lembang have low level. In the case of Lembang lakes, in 2009 total coliform and *E. coli* level did not exceed the maximum standard, although in 2010 and 2011 the total coliform level increased to be higher than the standard. A similar condition appear in Elok which is located in a High-Raised Residential Area. High level of total coliform also was measured at urban lakes surrounding DKI Jakarta region. However, *E. coli* concentration is still in the permitted level. Only *E. coli* in Rawa Kalong which is located in Industrial Area exceeded Indonesia Water Quality Standard, but not exceed standard of Governor Regulation.

Discussion

In this study, we use two kinds of Indonesian water quality standard as describe in Government Regulation PP No. 82 (2001). This is general water quality standard for water of agriculture or aquaculture use. This water quality standard recommended maximum total coliform bacteria 10000 CFU/100 mL and *E. coli* 2000 CFU/100mL. For urban lake in DKI Jakarta, we use local government regulation that is DKI Jakarta Governor Regulation number 582 (1995) for river water that allowed total coliform to maximum of 20000 CFU/100 mL and *E. coli* 4000 CFU/100mL.

Megacity Jakarta (Jabodetabek) consisted of DKI Jakarta as capital of Indonesia and other surrounding 7 local governments that are Bogor Regency, Bogor City, Depok City, Tenggerang Regency, Tanggerang City, Bekasi Regency and Bekasi City. DKI Jakarta has own regulation, but these local governments have no regulation. Our research used these regulations.

Figure 1 (top) shows that total coliform bacteria level of several urban lakes in DKI Jakarta increased every year. In 2009, only 7 urban lakes have high concentration of total coliform exceeded water quality standard. In 2010, 10 urban lakes had higher level concentration of total coliform. Moreover, in 2011 the condition was worsened as 12 urban lakes had total coliform above the standard.

Coliforms are bacteria associated with environmental sources such as soil or fecal material. Total coliform found in the water of urban lake indicates that disease caused by microorganism

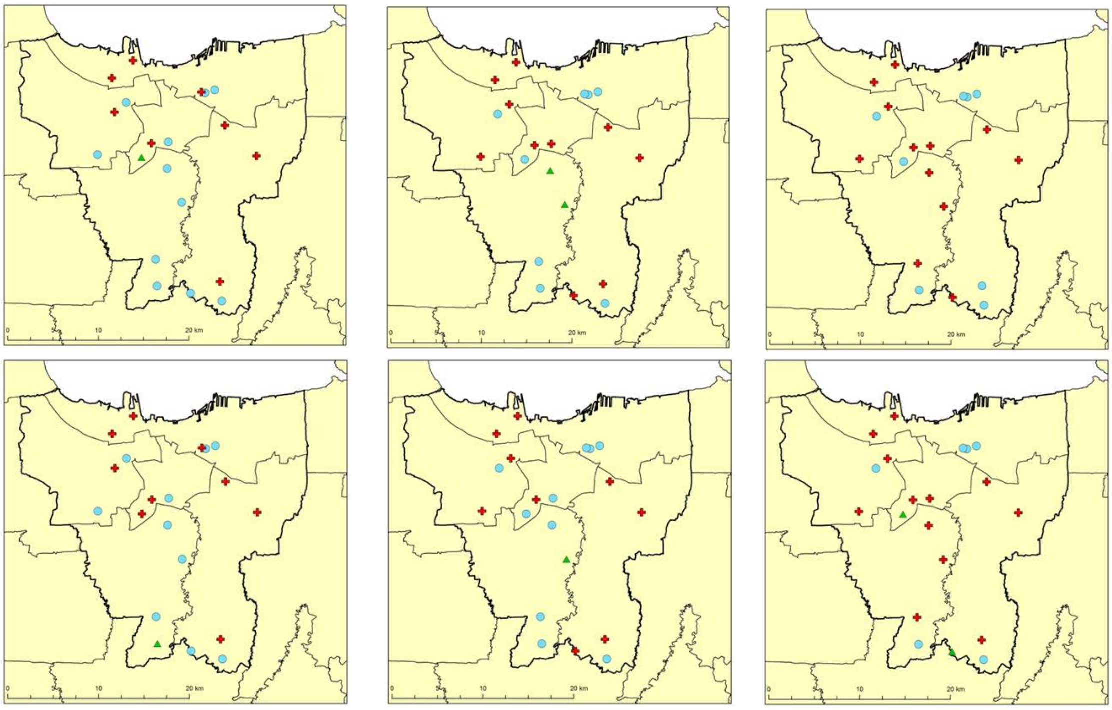

Fig. 1. Total Coliform (top) and *E. coli* (bottom) levels in urban lakes DKI Jakarta in year 2009 (left), 2010 (middle) and 2011 (right). For total coliform count, blue circle shows less than 10000 CFU/100mL, green triangle is between 10000 to 20000 CFU/100mL, red plus is over 20000 CFU/100mL. For *E. coli* count, blue circle shows less than 2000 CFU/100mL, green triangle is between 2000 to 4000 CFU/100mL, red plus is over 4000 CFU/100mL.

may be present. Moreover, in 2010 and 2011 higher concentration of total coliform indicated strongly that other more harmful bacteria might be present. When levels are higher, there may be an elevated risk of waterborne gastroenteritis.

For *E. coli*, in 2009 and 2010, 9 urban lakes had high level above the standard, although the level varied. For instance, E. coli level at Kalibata lake increased slightly, but at Taman Ria Senayan lake it decreased to the level below water quality standard. However, in 2011, *E. coli* level increased in many urban lakes, as 12 urban lakes had *E. coli* level above the standard (Figure 1, bottom). The existence of fecal coliform, particularly *E. coli*, indicated the existence of mammal or bird feces in the water.

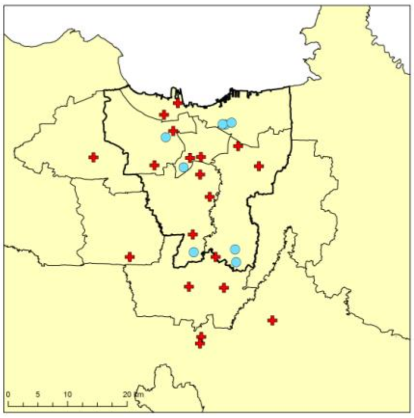

Fig. 2. Coliform in urban lakes megacity Jakarta in year 2011. Blue circle shows less than 10000 CFU/100mL, green triangle is between 10000 to 20000 CFU/100mL, red plus is over 20000 CFU/100mL.

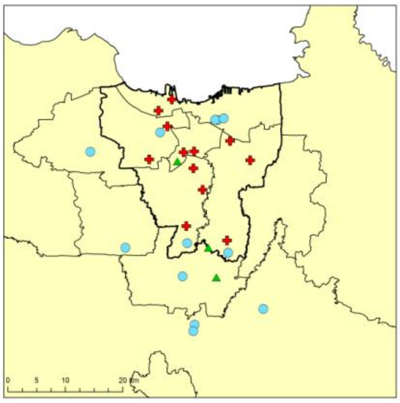

Fig. 3. *E. coli* levels at several urban lakes in megacity Jakarta in year 2011. Blue circle shows less than 2000 CFU/100mL, green triangle is between 2000 to 4000 CFU/100mL, red plus is over 4000 CFU/100mL.

One of the reasons might be effect of climate change. Bates et al. (2008) identify that higher water temperatures and changes in rainfall will affect water quality and exacerbate many forms of water pollution, with negative impacts on ecosystems and human health.

Figure 2 shows total coliform bacteria of urban lakes in megacity Jakarta. It shows that high level of total coliform also could be found in other cities surrounding Jakarta. None of urban lakes in these cities have total coliform level allowed below the standard. Although they have high level of total coliform, *E. coli* level of those urban lakes is below the standard (Figure 3).

Acknowledgements

This research is funded by both Research Institute of Humanity and Nature (RIHN) and Toyota Foundation. The authors would like to thank BPLHD DKI Jakarta who had provided the urban lakes data.

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The Lake Trasimeno: exploitation and defense of the resources of the lake. The break of an ancient balance between 18th and 19th century

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Keywords: Trasimeno, lake, environment, resources, Etruscan

Introduction

Origin of the name

Since antiquity the Lake Trasimeno was the core of several productive activities, as shown by the archaeological evidence. An interesting case is the one given by the Etruscan *Tabula Cortonensis* (Agostiniani & Nicosia, 2000). The *Tabula Cortonensis* (Fig. 1) is a bronze tablet, 45.5 cm high and 28.5 cm large, written on both sides with a ca. 200 word long Etruscan text, broken into eight fragments (whose only seven survived), dealing with the selling of some parcels of land from a group of people to another group of people, with a third group named as witness. The *Tabula*, written approximately around the 2nd century B.C., was probably found in 1992 near Cortona, in Tuscany, during some home-building excavations. On the back side there is a sentence concerning something that has to be done *celtinêi tisś tarsminaśś*, that is,

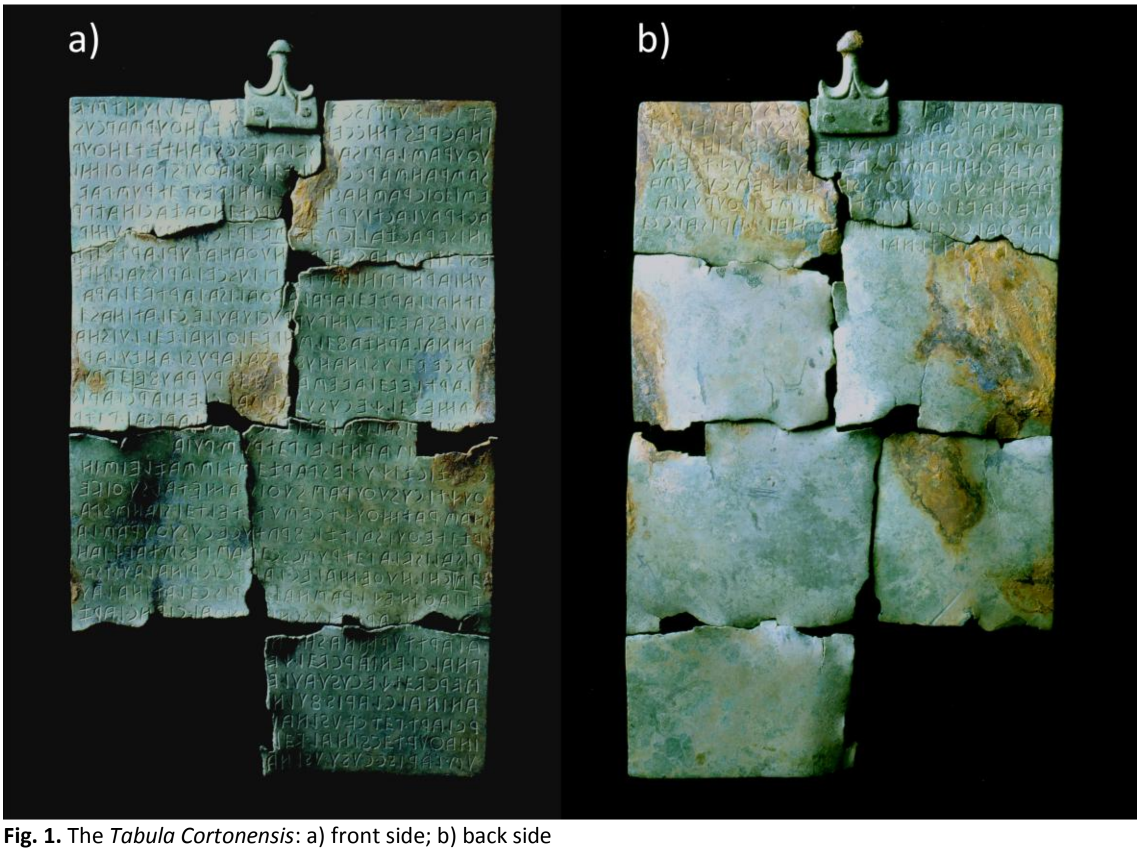


Fig. 1. The *Tabula Cortonensis*: a) front side; b) back side

according to most scholars (e.g. Agostiniani & Nicosia, 2000: 113−114), “in the fields of the Lake Trasimeno”. In fact it is very likely that the name “Trasimeno” belonged originally to the Etruscan language: this would explain some uncertainty in rendering this name in Latin literature (*Trasimenus*, *Trasimennus*, *Trasymenus*, *Trasumenus*, *Trasumennus*, *Tarsumennus*) as in the Greek one (*Ταρσιμέννη λίμνη*). Ancillotti (2008) even suggests that *tarsminaś*, though Etruscan, might have belonged originally to an ancient Indo-European layer, and its meaning be “the one which drains”, relating to the most prominent feature of the Lake Trasimeno, namely the fact that it periodically drains out and than fills back with water. Ancillotti's hypothesis requires further investigation concerning the laws of sound change in Indo-European linguistics, and the fact that such a linguistic layer is not witnessed by any text represents unfortunately an obstacle; in fact, his hypothesis is based mainly on toponymy. However, the idea that “Trasimeno” might have meant originally “the one which drains” is in any case a fascinating suggestion.

On the whole, the case of *Tabula Cortonensis* suggests that since then the shores of the Lake were the object of productive exploitation, mainly of agricultural nature, probably pursued with settlements not different from Roman *villae*.

The break of an ancient balance

In the last millennia the Lake Trasimeno went through a difficult relationship with human settlements and productive activities. Slight movements of the level of water yield relevant movements of the shore line, and this makes the management of this area more and more difficult (Cattuto et al., 2011: 7–14, 17–45, 101–164).

At the beginning of 13th century the City of Perugia ruled the Lake and its surroundings. The rights on fishing and hunting, on farming on the shore fields – the so called *pedate* – and on the fields of the islands were not exercised directly, they were temporarily outsourced to private contractors.

For a long time, first the City of Perugia, later the Papal State kept the balance between exploitation and protection of such goods. The rules and laws of that time, on the whole, are an example of good management: with the amount of local practices, they constitute a legacy of knowledge of great interest.

The whole lake basin was under such control. Oak woods were protected. Thousands of tons of tree branches were required to make the offshore underwater fish burrows work properly. In the half of 15th century two thousands of permanent fishing settlements – the *Tori* – were active. In wintertime the tench (*Tinca tinca*), the pike (*Esox lucius*) and the eels (*Anguilla anguilla*) used to seek refuge there and were hunted with big seines. The canals that took water to the Lake were kept carefully through periodical maintenance. Even the lake bottom was safeguarded, because it was where the tench used to look for warmth in wintertime. Fishing was restricted during the breeding season and in summertime. Restriction affected also the fishing equipment and techniques that were considered harmful. Proper rules affected when and how to cut the marshy vegetation that surrounded the shore; what was cut was later sold for its purposes. No grazing animal was allowed to get into the cane thicket where fish used to breed. Fields above the *pedate* belonged to private owners, while the *pedate*, the fields along the shore, belonged to the community.

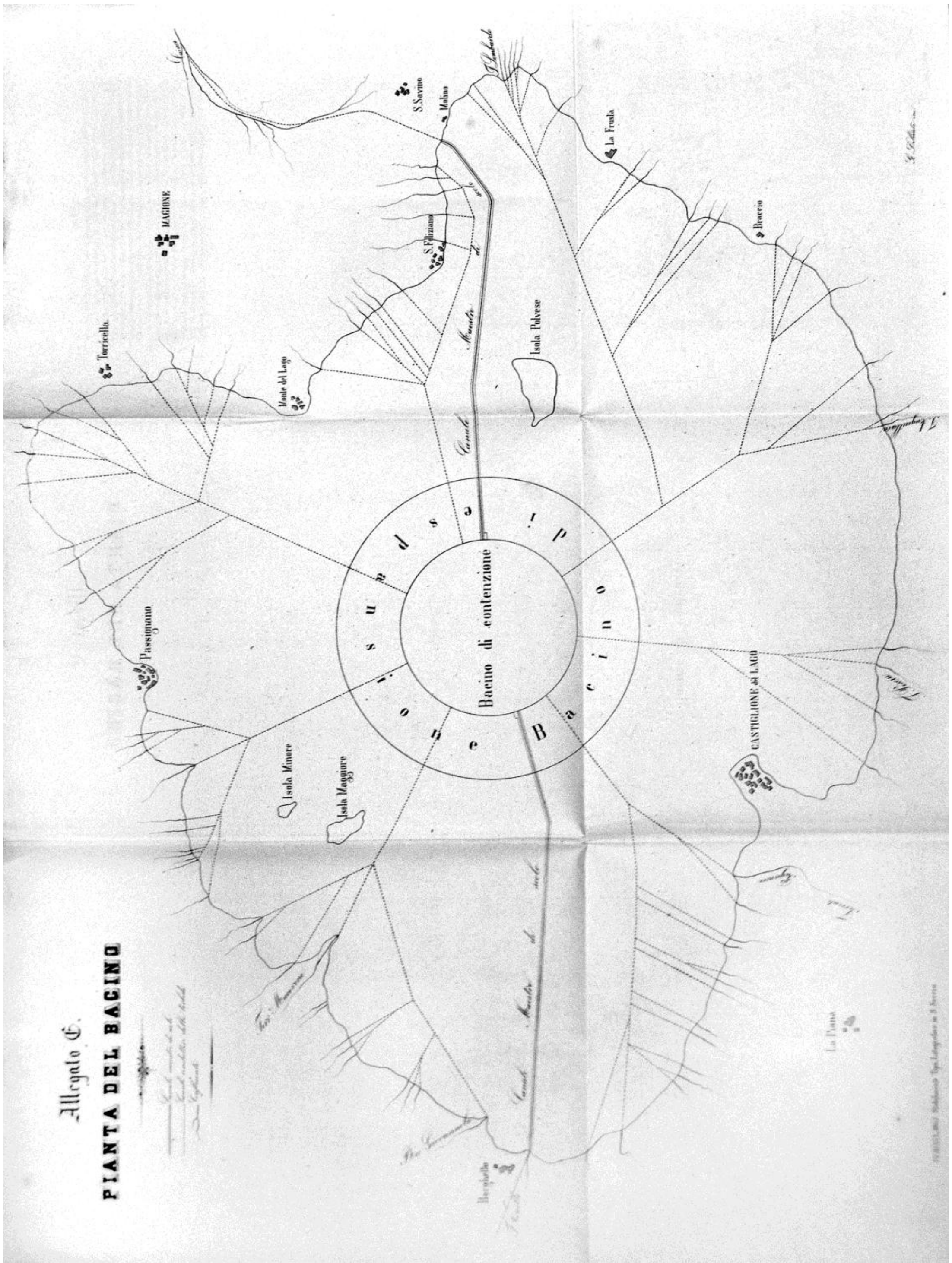


Fig. 2. Project of drainage by Ing. Barilari, 1865.

Tab. 1. Annual highest and lowest water levels of the Lake Trasimeno from 1882 to 2014. (Cattuto et al. 2011: 394–395 mod.).

edge level.

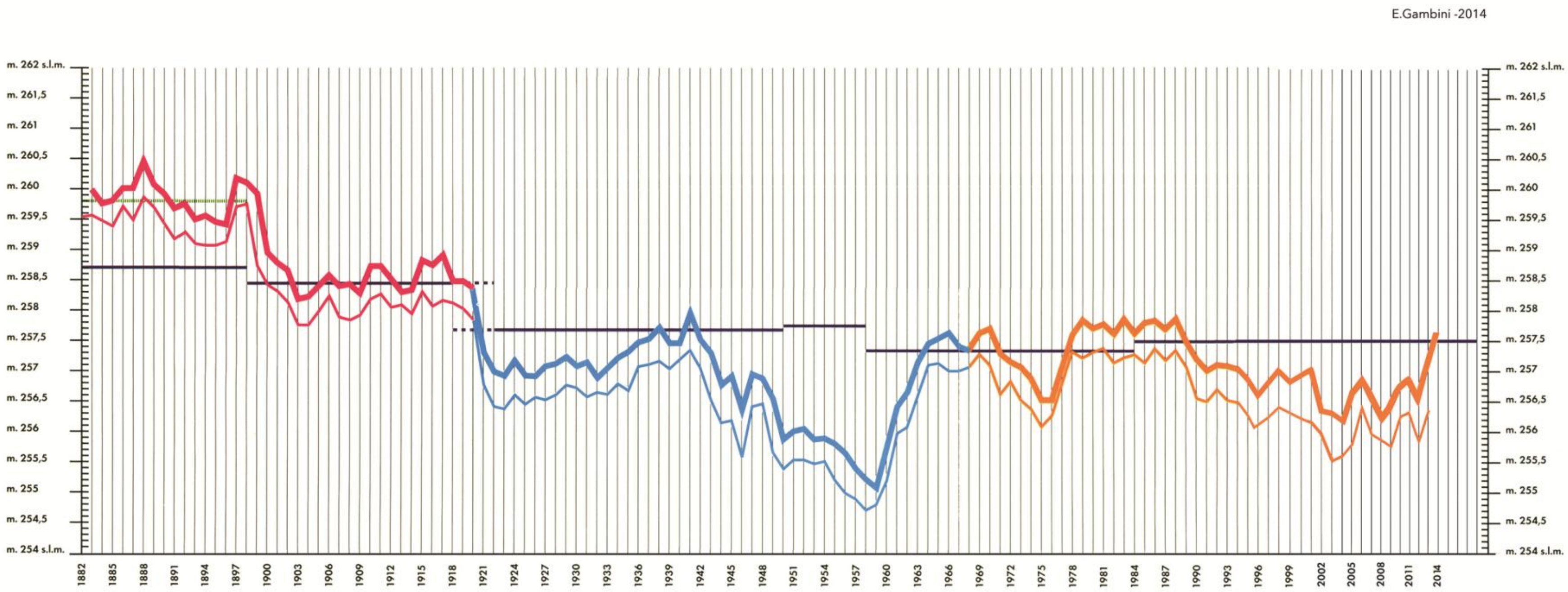
Blue line (1921–1968). Annual highest and lowest hydrometric levels (values taken the first day of each month).

Orange line (1969–2014). Annual highest and lowest levels, taken at the S. Savino hydrometer (m 257.33 above sea level).

Green dotted line. Average levels between 15th and 19th century (m. 259.80 ca. above sea level).

Purple line. Level of the edge of the floodway from 1882 to present.

Purple dotted line. 1918–1922. Years when approximately the edge of the floodway was reduced from m. 258.42 to m. 257.66 above sea level.



In the Statute of 1279, chapter 242, we read that, at the time when the Lake became a property of the City of Perugia, boundary stone pillars were planted on the line drawn by the flood of the Lake (Caprioli, 1996: I, 236–237). The City owned the whole lake and all the land that was left after the flood. This ensured the good management and the productivity of such a large lake through time, as it used to be since when the Roman Laws ruled. In Iavolenus, in the *Digestus* (D. 50, 16, 112), we see that when the shore of a lake (the so called *litus*) is public property its boundaries are set according to the maximum level of flood (Speroni, 2010: 529–530). The Lake of Perugia in rainy times was able to store enough water to face any drought year without problems; water fluctuating up and down ensured a large natural shore ground which was renewed periodically and constituted an ideal set for fish breeding.

Around 1770 the medieval floodway (1421−22) became inadequate to ensure the productivity of shore fields and the life of towns and villages, constantly under threat of flood. Farming productivity improvements pushed the farmers to take advantage of the shore fields and of the water of the lake for irrigation. At the end of 18th century and during the following century many projects of partial or total drainage of the Lake Trasimeno were submitted; in the most conservative ones the Lake was intended to be reduced to one or more basins for irrigation (Fig. 2). Only the steadiness of the City of Perugia and later of the Province of Umbria saved the Lake Trasimeno from a premature death.

After the end of the Papal State, as the control on the lake lost its effectiveness, fishing during summertime caused the reduction of the tench and above all of the roach (*Rutilus rubilio*).

A Consortium for Drainage was set by the local landowners. As a result, a new floodway was built (1896−98), 12 times bigger than the medieval one. Its toughtless use led the Lake Trasimeno to serious low level crises. To gain new land the edge of the new floodway was further reduced, thus closing the lake into a straitjacket. The environment loss was huge. In 1917 all the bigger permanent fishing settlements were abandoned.

The Consortium was held to be responsible of the serious low level crisis of the Lake in the first fifteen years after the Second World War (Ministero LL. PP., 1958: 2−6). No fish breeding was set in order to face the changes occurring in the fishing economy. Landholders refused to invest their money, abandoning the Lake and dropping out the usual maintenance.

The intent of exploiting the water of the Lake for irrigating purposes survived even in the 20th century, causing a new low level crisis, now overcome after twenty five difficult years (Tab. 1).

The knowledge of the life cycles of the Lake that inspired the past management should be recovered and stand as a heritage. New, economically sustainable solutions need to be found in order to avoid the use of farm slurry with water for irrigation and to ensure the maintenance of the cane thicket. The web of the canals need to be recovered and kept efficient. Our present scientific knowledge on such an ancient lake needs to be significantly improved, in order to offer it at its best to the following generations (Cattuto et al., 2011: 235−244).

Acknowledgements

We would like to thank Barbara Angeli for her helpful comments regarding the English version of this paper. Nonetheless, any mistake is only our fault.

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GOVERNANCE AND MANAGEMENT: PARTICIPATION AND CHALLENGES

Current IWRM Practices in Malawi and their Implications on Lake Basin Management

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Keywords: Integrated Lake Basin Management (ILBM), Integrated Water Resources Management (IWRM), water resources management assessment

Introduction

Malawi is endowed with abundant water resources which include Lake Malawi, a Great African Lake hosting the greatest freshwater fish biodiversity in the world (Bootsma & Hecky 1999). The country has a total renewable water resource per person of less than 1,400 m^3/year, making it a water stressed country (USAID, 2009). The National Water Policy (2005) advocates Integrated Water Resources Management (IWRM) as the basis for sustainable water development and all water resources management activities are required to apply IWRM principles. An Integrated Water Resources Management/Water Efficiency (IWRM/WE) Plan was developed in 2008 to guide the country in addressing its key water related challenges. The IWRM/WE Plan for the 2008 - 2012 period aimed to improve the livelihoods of the people through sustainable development, use and management of water resources. This study assesses the effectiveness of the implementation of the IWRM/WE Plan so far, highlights achievements made and challenges encountered, and draws insights on how to incorporate Integrated Lake Basin Management (ILBM) within the IWRM framework to ensure sustainable management of lakes in the Sub-Sahara African context. Considering that the IWRM concept seeks to attain a balance between water for livelihoods and water for nature, our objective is to assess whether or not the projects: (1) took into account all users; (2) utilized decentralized structures; (3) recognized women's role and improved their access to water; (4) empowered poor people, helped reduce poverty, improved livelihoods and promoted economic growth; and (5) collectively worked towards maintaining the resource base.

Methods

We reviewed a wide range of documents, published and unpublished. We also conducted key informant interviews in Malawi in April and May 2014, at the Departments of Water Resources, Environmental Affairs, Irrigation, Land Resources Conservation and Development (agriculture), Fisheries, Forestry and a few others. In the same period, we conducted a survey in the Lake Malawi Basin, targeting rural communities.

Results

Malawi is implementing IWRM through projects aimed at addressing the specific issues communities are facing. Our results are based on the experiences from these projects and general water resources management in the country. The areas assessed are explained below.

Is IWRM taking into account all users?
The priority has been on improving access to water in the rural areas. Major water users in this context are households, farmers (both small- and larg-sacle), fisherfolk and natural ecosystems, among others. The projects in the water sector are integrating these users in both the planning and implementation stages in an attempt to realize win-win situations wherever possible. Challenges include policy conflict among sectors in some cases and insufficient capacity at the local government level.

Is IWRM utilizing decentralized structures?
Generally, implementation is following the Traditional Authority Structures at the local government level (district councils). Where appropriate, Water User Associations (WUAs) have been established. The WUAs comprise of local users and they are given the responsibility to manage the water resources. The National Water Act (2013) requires the establishment of Catchment Management Committees (CMCs) in all river basins to be responsible for catchment management and they are required to advise the Water Resources Authority on water resources conservation, among others. These have not yet been established. However, there currently is a project in the largest river basin (Shire River) underwhich CMCs are in the process of being established.

Is IWRM recognizing women's role and improving their access to water?
Generally, access to clean water in Malawi is good. The country's MDGs target for 2015 is 74% and the Government of Malawi reported to have reached 81% access in 2010. Through our survey, we checked whether or not this achievement is reflected in the Lake Malawi Basin, the largest water catchment in the country consisting of several important river basins. Out of 510 responses, 85% had access to clean water, quite reflecting what the country had reported earlier.

Is IWRM empowering poor people, helping reduce poverty, improving livelihoods and promoting economic growth?
Most of the recent projects in the water sector have a livelihoods component and are designed to address a variety of needs e.g. linking dam development projects to irrigation schemes, fish ponds etc. Meeting multiple domestic and productive water needs is given the highest priority in the Southern African Development Community (SADC) IWRM demonstration projects in an approach termed "Local-Level IWRM". In this approach, poor people's multiple water needs and their priorities are the starting point of the planning and design of new infrastructure or rehabilitation and sustainable management of institutions (Koppen et al., 2009). This has proven to be a better approach from the experiences of the demonstration projects in which Malawi also participated.

Is IWRM collectively working towards maintaining the resource base?
Maintaining the resource base entails managing the catchments in a way that ensures sustainability of all dependent ecosystems. This includes protecting catchments from

degradation, rehabilitating degraded catchments, maintaining natural habitats etc. To some extent, some of these activities are integrated within the activities of the local management committees e.g. irrigation farmers implementing river bank protection activities, communities maintaining local forests etc. However, a lot more needs to be done as much of the catchment management is still fragmented, with the forestry sector playing a major role. The CMCs would be better placed in managing catchments in a way that ensures sustainability of the resource base. Current challenges include hiccups in decentralizing catchment management. IWRM is currently following the decentralization structures where the local government plays a central role. Many river catchments however cut across two or more districts. This calls for a decentralized catchment management system that is able to cut across district jurisdictions wherever necessary.

Discussion

Malawi's water resources management has placed much attention on water resources development than on conservation. The focus is on improving access to water resources through provision of new infrastructure or rehabilitation of existing ones. This is justified because from the perspective of communities "improved water management" essentially means "improved access to water" (Koppen et al., 2009). Mulwafu & Msosa (2005) argue that access to water resources is an important factor to poverty alleviation because inter alia, poor people depend on water resources as a direct input for production and as a basis for health and welfare. Koppen et al., 2009 also observed that once water has been made accessible to communities, they tend to utilize it in their own innovative ways to improve their wellbeing e.g. engaging in small enterprises such as mat and basket weaving, brick making etc. However, it is important for the country to also place considerable attention on catchment conservation and protection to ensure that the resource base on which these poverty alleviation activities depend is sustained.

To ensure continued integration especially with respect to the various service providers under the IWRM umbrella, sufficient and stable resources need to be available to cover expenses related with the involvement all affected stakeholders e.g. coordination. Currently, many integration efforts rely on funds from projects and implementation is difficult where there are no projects due to resource constraints. Local governments play a central role in pursuing this integration and therefore, adequate resources should be provided for their coordination and supervision role.

Many of the problems that lakes are facing originate from their catchments. For example, the major problems Lake Malawi is facing are a result of deforestation, uncontrolled bush fires, poor land husbandry, pollution from agricultural activities, heavy extraction of water for irrigation from some rivers, etc. originating from the catchment. The lake catchment comprises of several river catchments making IWRM very relevant to ILBM since the approach provides the starting point. If the river catchments are sustainably managed, incorporating the unique characteristics of lakes of integrating nature, long retention time and complex response dynamics, sustainable lake basin management will follow. Therefore, establishment of CMCs should be given priority as their envisioned role is essential in realizing sustainable management of water resources.

Acknowledgements

We appreciate the assistance of the various institutions of the Government of Malawi in providing information and data.

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Approaches by the Ibaraki Prefectural Government to Improve Water Quality in Lake Kasumigaura with Forest and Lake Environment Conservation Tax

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Keywords: Local government, Local tax, Lake Kasumigaura, Grant, Ibaraki prefectural government

Introduction

Lake Kasumigaura (the general term for Lake Nishiura, Lake Kitaura, and Hitachitone River), the second largest lake in Japan, is located in the southern part of Ibaraki Prefecture in the eastern part of Japan, facing the Pacific Ocean（Fig.1). The lake is relatively shallow, with an average depth of four meters. About one million people live in the lake basin, and lake water is used as tap water, industrial water, and agricultural water. There is also a thriving fishing industry on the lake. Water pollution of Lake Kasumigaura increased from the 1960s owing to economic development and a rise in population. This has had a detrimental effect on irrigation and environmental conservation. Consequently, in 1982, an ordinance was passed for the prevention of eutrophication of Lake Kasumigaura, and a master plan for the prevention of eutrophication of lake waters was agreed. Ibaraki Prefectural Government is striving to reduce the environmental load on the lake and is implementing measures against pollution based on the 1987 plan for conservation of lake-water quality. However, the water quality of Kasumigaura has not improved since the 2000s, with a chemical oxygen demand (COD) of 7–9 mg・L^{-1} (environmental standard 3 mg・L^{-1}). To address this, Ibaraki Prefectural Government introduced the forest and lake environment conservation tax in 2008 and has promoted environmental conservation of the lake and responsible forestry management in the Kasumigaura basin. As of 2013, the environmental conservation tax for lakes and forests has been introduced in 33 prefectures,

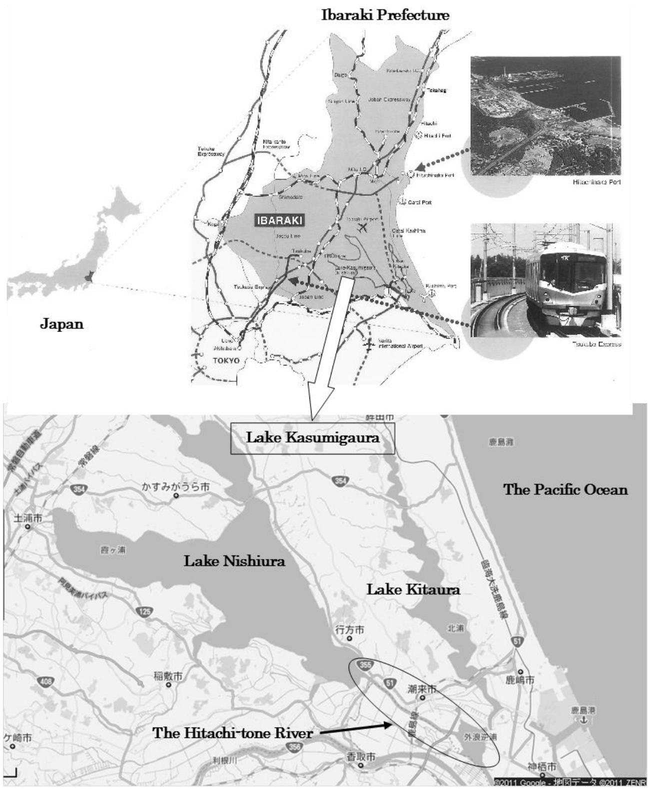

Fig.1. Location of Lake Kasumigaura

the first being Kochi Prefecture in 2003. About this time, I reported on the water quality of Kasumigaura in recent years and the measures against pollution of the lake taken using the forest and lake environment conservation tax.

Description of the forest and lake environment conservation tax

The taxable period of the forest and lake environment conservation tax in Ibaraki Prefecture is ten years (2008–2017). The tax rates for one year are 1,000 yen for an individual with an address in Ibaraki Prefecture, and 10% of an equally divided prefectural corporation tax for corporations with an office in Ibaraki Prefecture. The income from tax revenues for one year is about 1,600 million yen. Half the total tax revenues are used for forest conservation, and the remaining half are used for measures against water pollution of Lake Kasumigaura.

Measures against water quality purification of Lake Kasumigaura

The measures against water quality purification of Lake Kasumigaura that were implemented from 2008 to 2012 are summarized in Table 1.

Measures concerning household effluents, etc. (point source）

The connecting of agricultural communities to proper sewerage and drainage facilities was strongly encouraged. Installation of combined-type septic tanks was facilitated to reduce the load on Lake Kasumigaura from household effluents. On-site inspection of factories was performed to check drainage, and help was given for the installation of plant for composting livestock excrement.

Measures concerning agricultural drainage (non-point source）

Paddy fields are widely distributed along Lake Kasumigaura. Agricultural drainage-water flows directly into the lake through bank-based water canals. To ameliorate this, a circulating irrigation system that controls the load on Kasumigaura by returning irrigation water to the paddy fields was established.

Facilitation of water conservation activities by citizens of Ibaraki Prefecture

To facilitate the improvement of water quality by local citizens, equipment for environmental studies and activities, etc., was lent out at no charge. Civic organizations were helped

1. Measures concerning household effluents etc (point source)		
Financial assistance for installation of Combined-type septic tank	6,089	Cases
Financial assistance for connection of a sewer	4,814	Cases
Financial assistance for connection of drainage facilities for agricultural communities	959	Cases
On-site inspection in factorys	2,785	Places
Financial assistance for installation of plant for composting livestock excrement	52	Places
2. Measures concerning agricultural drainage (non point source)		
Financial assistance for installation of plant for curculating irrigation institution	43	Places
3. Facilitation of water preservation activities by participating in citizen of Ibaraki prefecture		
Financial assistance for lending for nothing of activity equipment and activity of civic organization	84	Groups
The tour for experiencing examination of water in a ship on the Lake kasumigaura	38,166	People
Assist for conservation activity of reed field	6	Groups

Table 1. The state of implementation of the measure concerning water pollution granted with Forest and Lake Environment Conservation Tax (H20-24)

financially in undertaking environmental activities. Given the importance of education about water environment conservation, ship tours of the lake demonstrating about water quality were organized for schoolchildren, junior high school students, and adults. Because of the importance of shoreline vegetation to breeding fish, measures to conserve the lake's reed beds were also implemented.

Conservation of waterside environment (lake and river)

Eutrophication and algal blooming are major problems for Lake Kasumigaura. Ibaraki Kasumigaura Environmental Science Center researched phytoplankton multiplication and the dynamic state of nitrogen, phosphorus, and organic matter in the lake and its associated rivers. It attempted to control algal blooming by installing ozonation and supersonic treatment equipment in the areas where blooms tend to occur. Patrols checking for algal blooming and sample collection were also carried out.

Water quality in Lake Kasumigaura

Change in long-term water quality of Lake Kasumigaura is shown in Fig.2. When the forest and lake environment conservation tax was introduced in 2008, annual average COD was 8.8 mg・L^{-1}. By 2012, it was 7.8 mg・L^{-1}. Annual average of T-N (total nitrogen) was 1.3 mg・L^{-1} in 2008 and 1.0 mg・L^{-1} in 2012; annual average of T-P (total phosphorus) was 0.12 mg・L^{-1} in 2008 and 0.084 mg・L^{-1} in 2012. As can be seen, water quality in recent years has tended to improve. However, T-N and T-P concentrations are still high (environmental water quality standard of T-

N is 0.4 mg・L^{-1} and that of T-P is 0.03 mg・L^{-1}). Therefore, phytoplankton levels may increase, and water quality may continue to worsen.

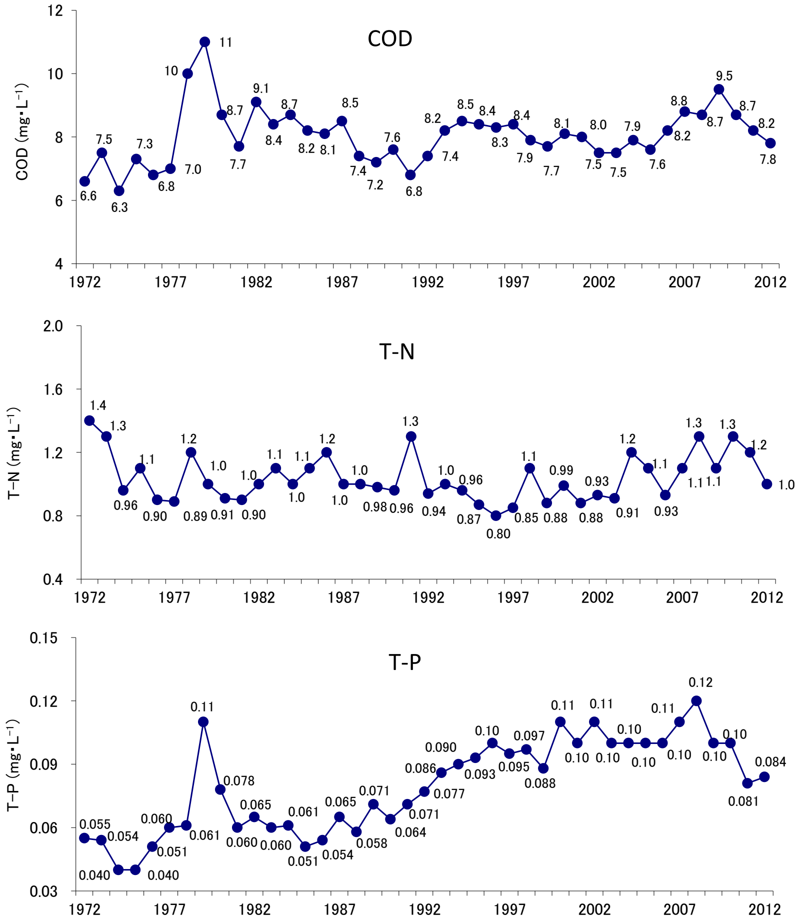

Fig. 2. Changes in Water Quality of Lake Kasumigaura

Conclusion

Although water quality of Lake Kasumigaura has tended to improve in recent years, it is still not meeting environmental water quality standards. Continued efforts are still required to improve water quality and implement further measures against water pollution.

Strengthening lake Chivero basin management technology pillar by Harare ILBM team, Zimbabwe

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Keywords: Lake Chivero, Local Environmental Action Plan, Marimba River, Mukuvisi River, Wetland

Introduction

According to a 2014 Agence France-Presse (AFP) article; towards the end of the 21st century, water stress is likely to affect billions and this could be an unseen driver of conflict. The hydrologists forecast that if current trends go uninterrupted, freshwater faces a double crunch -- from a population explosion, which will drive up demand for food and energy, and the impact of climate change (Ingham, 2014). "Approximately 80 percent of the world's population already suffers serious threats to its water security, as measured by indicators including water availability, water demand and pollution," the Nobel-winning Intergovernmental Panel on Climate Change (IPCC) warned in a landmark report in March 2014. To ascertain programs in the Lake Chivero basin a desk study was conducted in 2014 with the aim of bringing forth pollution levels and basin management strategies under implementation. The study focused on wetlands protection, urban agriculture and wastewater management among others.

Zimbabwe is a signatory to the Ramsar Convention on wetlands of 1971 and has domesticated provisions for the protection of wetlands under the Environmental Management Act Chapter 20; 27, Statutory Instrument 7 of the 2007 on the Environmental management (Environmental Impact Assessment and Ecosystem Protection). The Ramsar Convention embodies commitment by member states to maintain the ecological character of wetlands and to plan for the 'wise use' or sustainable use of all the wetlands in their territories.

Harare residents practice cultivation of crops on slopes, flood plains, wetlands, river banks and along servitudes, which practices have caused siltation leading to Lke Chivero siltation. Some of the effects of diminished water are reflected with residents resorting to digging unprotected wells thereby exposing them to diseases such as cholera, dysentery and typhoid. Harare suburbs are situated upstream Lake Chivero the main supplier of water hence these practices have a direct impact. To address urban agriculture challenges the Harare municipality has drawn up Local Environmental Action Plans (LEAP). Agriculture has changed Harare lifestyle dramatically, food and fiber productivity soared due to new technologies, mechanization, increased chemical use specialization and government policies that favor maximum production. Although these changes have had many positive effects and reduced many risks in farming which include prominent among these are topsoil depletion, groundwater contamination. Sustainable agriculture integrates three main goals namely Environmental health, Economic profitability, Social and economic equity. Sustainability rests on the principle that we must meet the needs of the present without compromising the ability of future generations to meet their own needs.

On the other hand discharges of partially treated wastewater with high nutrients load, especially phosphorous, has been the major challenge, and apparently if the discharges go uncontrolled the lake stand as a health time bomb. Indications are that sewage discharge rank very high in lake pollution with economic ripple effects on water treatment costs downstream at Harare's water treatment plant. Health concerns have been raised on Lake Chivero water quality. In response the health officials banned the consumption of fish caught in the lake, once a common food source for many Harare residents (Schwan, 2012). The City in 2009 embarked on massive wastewater plant rehabilitations and is currently on-going.

In the SADC region water has played a unifying role to spearhead cooperation in the Region with the Protocol on Shared Watercourses being the first treaty to be ratified at the level of SADC (Rampa and van Wyk, 2014).

Materials and methods

Data collection

Data used was gathered from the field campaigns conducted in the period 1999 to 2012, dry season samping done in October and the rainy season sampling in January of the respective years. The corresponding results were incorporated in the diagnosis of each river.

The laboratories involved for the corresponding nalysis were as follows:-

1. Analytical laboratories (Zimbabwean laboratory) for the analysis of pH, NH_4, NO_3, PO_4, TP, Iron, Mn, BOD_5, COD, TKN, dissolved solids, suspended solids, chloride, oil and fat
2. University of Zimbabwe Chemistry department Pb, Cd, Ni, As, Zn, Al, Cu, Cr, CN, oil, phenols and detergents
3. City of Harare Laboratory for the bacteriological analysis (Total Colifrom and Faecal Coliform).

Data conditioning

It could have been useful to compare the results with river quality criteria, however there was no Zimbabwean criteria for river water quality. Criteria from other countries such as USEPA guidelines were therefore used.

Location of sampling points

Rivers monitoring points as well as Lake Chivero outlet tower.

Selection of parameters

Water quality parameters related to urban agriculture, wastewater pollution and wetland protection were analysed.

Sampling method

The six criteria for quality data collection were followed i.e. collecting representative samples, formulating the objective of the sampling program, proper handling and preservation of samples, tracking chain of custody, sample ID procedures, field quality assurance and proper analysis (Tjandraatmadja *et a*l., 2009).

Testing methods

Sample analyses were in accordance with Standard Methods for the Examination of Water and Wastewater.

Results

The following preliminary results can be presented:

Sampling Site	Manyame	Marimba	Marimba	Lake Chivero
Depth	4	0	4	0
pH	7.9	8	7.7	9.9
Calcium (mg $CACO_3$/L)	46	54	56	36
Magnesium (mg/L)	28	32	56	38
Conductivity (uS/cm)	276	326	315	207
Ammonia (mgN/L)	0.43	2.92	3.4	Nil
Nitrate (mgN/L)	0.04	0.03	0.03	Nil
PO4 (mgP/L)	0.19	0.39	0.39	0.16
TP (mgP/L)	0.24	0.52	0.78	0.18
Iron mgFe/L)	0.36	0.84	1.44	Nil
Chloride (mgCl/L)	34	46	42	26
Sulphate (mgSO4/L)	59.1	51.1	51.9	40.1
BOD (mg/L)	8.2	14.8	15.6	5
TKN (mg/L)	8.4	18.2	15.1`	-
Dissolved Solids (mg/l)	126	258.8	252.8	149.2
Suspended Solids (mg/L)	39.1	55.4	83.7	3.2
Oil, Fat (mg/L)	15.3	22.5	23.7	7.9

Discussion

Mukuvisi and Marimba Rivers

- pH generally was in the neutral range 6 to 8 in Marimba and Mukuvisi Rivers
- Medium to high ammonia concentration, low nitrate concentration. Conversely, TKN was present in very high concentrations indicating the rivers were contaminated with organic matter, most likely linked to urban and industrial effluents.
- Orthophosphates concentration was in the medium to low during the dry season and very high during the rainy season. Total phosphates were present as orthophosphates during dry season and mainly present as organic phosphorous during the rainy season. The high level of total phosphorous corresponds to organic matter probably linked with washing of polluted urban areas.
- Organic matter was globally present at high concentrations both during dry and rainy season.
- Oil and fats concentrations were very high during the dry season which could be linked with the high levels of organic compounds. Lower concentrations were measured during rainy season probably due to a dilution process.
- Dissolved solid concentrations were low in the upper part of the rivers, and strongly increased downstream probably due to input from the water table and untreated sewage waters. Suspended solids were globally measured at higher value during dry season than during the rainy season.

- High concentrations of heavy metals were obtained during the dry season for lead, cadmium, and at a lesser degree for nickel and chromium. Arsenic concentrations were very high during the dry season and varied during the rainy season. Phenols concentrations were low in the upper reach of the rivers and may be high in the lower parts of the rivers.

Lake Chivero results

- The results obtained on nutrients concentrations confirm that Lake Chivero is a eutrophicated lake. The euthrophication is enhanced by the very important nutrient input from the rivers. Moreover, the sediments store nutrients that can sustain the euthrophic process at the occasion of a flooding.
- Heavy metals were high in raw water samples and low in filtered samples indicating that most of the heavy metals are bound to particles.
- The samples collected downstream of Lake Chivero did not present a heavy metal contamination of the measured PCBs compounds.

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Socioeconomic and Institutional Issues of Management of two Freshwater Lakes in West Bengal, India

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Keywords: lake; institution, conflict, West Bengal, India

Introduction

Lakes are one of the most important, yet threatened natural resources of West Bengal, India. A vast area of West Bengal is covered by different types of aquatic ecosystems mainly lakes, rivers and wetlands (SAC, 2010). Apart from supporting a huge amount of biodiversity these waterbodies play an important role in providing different types of ecosystem services to the local people. However, despite of its importances, the lake ecosystems in West Bengal are threatened from the pressure of the development need of the millions of poor people. The huge amount of population pressure and improper institutional arrangement are two of the main factors for degradation of the lakes (Reddy & Char, 2006; Sen, 2007; Das, 2012). There is a research gap in detail analysis of the socioeconomic and institutional aspects of lake management in West Bengal.

The present study makes an attempt to find out the dependency of the surrounding community on the lake ecosystem. Moreover, it tries to find out the underlying institutional mechanisms affecting the management of the lakes.

Materials and methods

Two lakes were selected from the Gangetic Alluvial Plain and the Red Lateritic Zone of West Bengal respectively. The selected lakes are Chupi-char lake (or Purbasthali oxbow lake), situated at the border of Burdwan and Nadia district of West Bengal and Barabundh lake (a man-made water harvesting structure) located in Bankura district of West Bengal (Fig. 1).

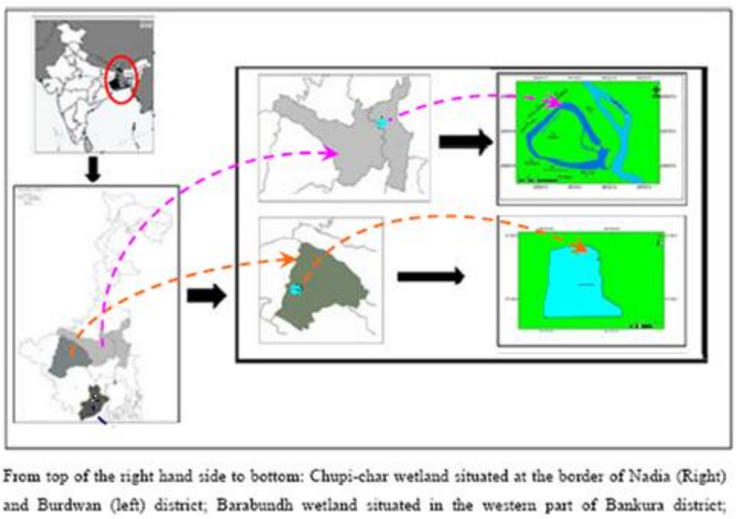

Fig. 1. Location map of the study area

Data on the socioeconomic condition of the households of the area around these lakes were collected by key informant's interview, focus group discussion and household survey. The social and economic factors determining the use of lakes for different purposes were identified by tobit and logit models. The market price method was used to calculate the imputed value of different products collected from the lakes. The institutional dynamics associated with these lakes were assessed by focus group discussion and key informant's interview. The study was carried out in 2011-2012.

Results

Livelihood and Economic dependence

Local people depend upon the two lakes for a variety of purposes like irrigation, fishery, cultivation in the sides of the lake, collection of fodder, jute retting, etc. However, the extent of these benefits varies from one place to another (Table 1).

The results of the tobit and logit models show that the models are overall significant. The livestock size is positively significant to the imputed value of the products collected from the lakes for pooled data and Barabundh lake. The social caste background is negatively significant to the pooled data and Chupi-char lake. Landholding size is negatively significant to the imputed value for pooled data, Chupi-char lake and Barabundh lake. These findings indicate that socially and economically backward section of the society depends more on the common pool resources like lakes than the advanced sections as mentioned in most of the literatures on the common pool resource. The combined result of the logit model shows that the social caste and landholding size are positively significant to the access to the lakes for irrigation. This indicates that upper caste people with more amount of landholding size are preferred for getting irrigation access over the socially backward sections with very little or negligible amount of land holding. This is common for traditional rural society of India, where social caste plays determining role in the use and access of resources.

Name of the benefit	Number of the households derive benefit from	
	Chupi-char	Barabundh
Fishery	44 (58.67)	58 (77.33)
Cattle feed collection	6 (8)	48 (64)
Leafy vegetable collection	9 (12)	21 (28)
Jute retting	24 (32)	0 (0)
Irrigation	36 (48)	44(58.67)
Crop cultivation in the side of the lake	4 (5.33)	0 (0)
Household purpose	60 (80)	57 (76)

(Number in the Parenthesis shows the corresponding percentages)

Table 1. Different types of benefits derived from Chupi-char and Barabundh lake by respondent households

Institutional aspects of the two lakes

Both Chupi-char and Barabundh have gone through different types of institutional dynamics over the time. Chupi-char was formed due to the change the course of the Bhagirathi-Hooghly River. Change of the river course caused land right problems which ultimately resulted in the encroachment of the sides of the lake by the farmers and conflict between the farmers and fishermen. Two fishermen cooperative societies and five numbers of Water Users' Associations are operating on the lake. Most of the people perceive that both of the co-operative societies have become socially irrelevant due to corruption and lack of decentralization. They also opined that these societies do not take care of the need of most of the traditional fishermen dependent on the lake. The Water Users' Associations receive enough water from the lakes and they operate at very small scales. So they are not interested to take any measure for the restoration of the lake. There is also a conflict between the fishermen of the two districts related to the boundary issues. Due to these multiple levels of conflicts and the defunct condition of the co-operative societies, there is no regulation against unsustainable practices like the use of very fine nets for fish catching, wastewater discharge, encroachment of the lake, excessive amount of jute retting, etc. The lake has become silted, infested by water hyacinth and showing the symptoms of eutrophication. The aesthetic value, navigation, fishery and household use have been greatly affected.

In case of Barabundh, there is a conflict between *de-facto* and *de-jure* property rights among the upper caste Brambhin families and local tribal families. Due to these conflicts there is no regulation in resource use and no collective action can be taken for the restoration measures like dredging, maintenance of the embankment, etc. These have affected different types of activities like irrigation, fishery, household water use, livestock rearing, etc.

According to the local people, the local administrations do not have any role in conflict resolution for sustainable use of the lakes.

Discussion

The surrounding people depend on the two lakes by different ways like using fresh water for household purposes, irrigation; fishery; jute retting; collection of fodder for livestock; grazing; collection of leafy vegetables, etc. The socially and economically marginalised section of the community depends more on the lakes for collecting different products like fish, shellfish, fodder, whereas the upper caste people have more access to the lakes for irrigation. In spite of the importances of these lakes, in both the cases, absence of clear of property right has caused mismanagement of the lakes. There is no comprehensive policy for the lakes and wetlands in India and specifically for West Bengal. Some of the national level programmes on lakes and wetlands and few of the rules and regulations against the degradation of the aquatic ecosystems do not provide any sustainable conflict resolution mechanisms. Central and state government should come up with a comprehensive policy for lakes and wetlands considering its biophysical, socioeconomic and institutional dynamics. Sustainable livelihood diversification by a mix of farm and non-farm activities can open up possibilities for sustainable management of the lakes. Establishment of vibrant local institution is essential for enforcement of rules and regulations. Local institution should be well connected with the local administrative bodies and line department of the government. Non-government organisations should be involved in awareness generation and institution building procedure.

Acknowledgements

We are thankful to a number of people for this study, especially Dr. Dhrubojyoti Ghosh, Special Advisor, IUCN; Dr. Subir K. Ghosh, Thematic Group Lead, Ecosystem Management Group (Capacity Building), IUCN; Dr. S. C. Santra, Professor, Department of Environmental Sciences, University of Kalyani; Dr. A. K. Nandi, Associate Professor, Department of Agricultural Economics, Bidhan Chandra Krishi Viswavidyalaya; the scientists at the Institute of

Environmental Studies and Wetland Management (IESWM), Kolkata for their valuable suggestions. We also acknowledge the co-operation of to the Department of Fisheries, Government of West Bengal and Mr. Raja Chatterjee, Secretary, *The Junglees*, for providing us the necessary information during this study. We are also thankful to the villagers for providing data related to the use of the lakes. We are indebted to the friends and colleagues for their valuable suggestions and inspirations.

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A tool for sharing best practices in lakes basin management.

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Keywords: Lakes Basin management, Best practices, GIS analysis, Deming cycle, knowledge and capacity sharing.

Introduction

Possible ways of improving organizations are to identify, communicate and facilitate the transfer of practices that seem to work successfully somewhere else. The purpose of the present work is to present the project "Best Practices for Lake" (BP4L) , aimed to explore outcomes and share lessons learned from the best practices applied in the sustainable management of lake areas by local authorities and other stakeholders. The primary goal is the selective observation of a set of exemplars across different contexts to derive more generalizable principles and theories of proper lake area management. This aims at enhancing knowledge and capacity exchange, involving different kind of stakeholders: researchers, environmental practitioners, local authorities, private actors and civil society.

Materials and methods

The BP4L aims to bring together the international scientific community with the local authorities and other stakeholders for the dissemination of good practices relating to the management of areas adjacent to lakes.

The main goal of BP4L inspired to the Best Practices Research field is to foster the improvement of the way of working of an institution, by adopting certain principles of another institution that appear to be more successful (Bardach, E. 1994). The study consists of two basic elements that are referred to as *target site* and *source site*. Target sites are institutions whose way of working needs to be improved, while source sites are institutions providing inspiration for such an improvement

First, we need to analyze the target site and to find out in which aspects the institution falls behind others, where are the main problems and what is needed to reach an improvement on the basis of a clear definition of the goals, especially important for non-profit and public institutions with their various missions and purposes of activity.

Further steps, referred to as *explanation of the process*, are oriented to answer the question "how?". Therefore, we look for exemplars of working practices that appear superior, compared to those in the target site. The key to the success is to find exemplars which are worth to be followed and, among them, to select the best one. Finally, in the *extrapolation step*, we convert the experience from the exemplar to the target site (Veselý, A. 2011).

A good basin management of a lake can be realized only through a continuous improvement of the lake basin governance, that integrates institution policy, participation, science, technology and finance (Nakamura et al 2012). The table 1 summarises the development phases of the BP4L model, through a Deming cycle Plan-Do-Check-Act.

<table>
<tr><th></th><th>Obj 1
Spatial analysis</th><th>Obj 2
Knowledge sharing</th><th>Obj 3
Communication</th></tr>
<tr><td>PLAN</td><td>Description of the problem, formulation of the objectives, definition of the research fields</td><td>Assessment of knowledge and tools of practices sharing</td><td>Development of the communication plan</td></tr>
<tr><td rowspan="2">DO</td><td rowspan="2">Realization of actions, selection of the potential usersthrough GIS and indices development</td><td>Public announcement and selection of the experiences submitted</td><td>Direct and indirect involvement of the potential users</td></tr>
<tr><td colspan="2">Scientific, inclusive, participate cultural and public events
Face to face with experts
Publications</td></tr>
<tr><td>CHECK</td><td>Description and verificationg of results</td><td>Comparison of results with objectives</td><td>Monitoring success of trial.
Attendance</td></tr>
<tr><td rowspan="2">ACT</td><td>Quantitative geospatial analysis</td><td>REPOSITORY: in a public official Data base (Gelso)
Monitoring</td><td>Reflecting of processes</td></tr>
<tr><td colspan="3">Standardization of successful approach.
Standardization of successful results.
Quality improvement.
Starting follow-up actions.</td></tr>
</table>

Table 1. Deming cycle of BP4L project.

For the definition of the target users we focused on municipalities. We applied additional selection criteria under the hypothesis that the two variables, lakes and municipalities, are defined through the following general functions:

Lakes = f (vl, n, AL)

Municipalities = f (vm, AC, ACL, LC, CL)

where:

- n = Presence of a proper name of the lake;
- AL = Total area of lake;
- vl = Vulnerability function related to lakes (uses, water quality, etc)
- AC = Total area of the municipalities ;
- ACL = Total area of the lake portion in each municipality;
- LC = ACL/AC Percentage of the municipal territory occupied by the lake
- CL = ACL/AL = Percentage of the lake area that falls within each municipality
- vm = vulnerability function related to the municipality (demographic driven, land use, economic outcomes, etc)

The post-processing phase consits into highlighting excellences and critical situations and collecting a dynamical and geographical repository.

Results and discussion

On the basis of the data available in the Italian Geoportal of the Ministry for the Environment, Land and Sea, we developed the project plan relating to lakes and ponds surveyed on the Italian territory (Table 2). The ponds initially surveyed in the Italian territory are 993 for a total occupied surface of 1982 km^2. These ponds fall on 838 municipalities and 91 provincial territories, and each of the 20 Italian regions contains at least one lake. The total area of the involved municipalities is 59236 km^2.

In order to refine the research by excluding very small ponds and artificial irrigation reservoirs, we selected only those lakes with an area greater than 50000 m^2. This allowed to reduce the analysis to 599 lakes.

Then we also excluded all those lakes whose name was missing(i.e. null attribute name in the field of the database), thus further reducing the total number of lakes to 351 lakes, which represent almost the 35% of the initial lakes population and corresponds to a total surface of 1822.82 km^2.

The selection was conducted through a pre-selection and a final identification of three different target groups, defined in table 2 as Target A, Target B and Target C, through the use of the indices defined above.

LAKES			MUNICIPALITIES		
	AL kmq	**N°lakes**	**LC**	**CL**	**N° municipalities**
Name=NULL	0,05<A<0,15	**86**	>20	100	**TA = 88**
	0,15<A<1	**132**	>20	100	
	1<A<5	**88**	>20	>40	**TB = 113**
	5<A<10	**21**	>20	>40	
	A> 10	**24**	>30	>0	**TC = 71**

Total: 255

Table 2. Selection criteria depending on the variables lakes and municipalities.
TA=Target A, TB=Target B, TC=Target C are the users that are defined by different thresholds.

The selected municipalities were then invited to submit projects for the BP4L Award (2014, 1st Edition) entitled "Virtuous experiences in the sustainable management of lake areas" and promoted by the Italian Ministry of Environment, the Italian High Institute for Environmental Protection and the Institute for Environmental Protection and Research - ISPRA, La Sapienza University of Rome, and the University for Foreigners of Perugia. This initiative aims at selecting projects for the best practices in sustainable management of lake environment.

The best practices should have made an outstanding contribution to the environmental conservancy of lake areas, integrated into the social and economic development on a sustainable basis. Moreover, these practices should be transferable and flexible. The practices could focus on a variety of sectors such as: urban planning, energy, engineering and hydraulic works, waste management, landscape conservancy, tourism and culture heritage, integrated and inclusive strategies.

The communication plan has been developed on two levels: 1-, potential users (municipalities) were contacted directly by the most accredited Italian institutions (Ministry and Academic institutions); 2- an information campaign through the social network and the mass media has been performed in order to involve other stakeholders

The sharing of knowledge was realized through scientific and educational events at the 15th World Lake Conferences which was held in Perugia in September 2014. The main findings from the selected projects are going to be inserted into the ISPRA database, named GELSO - Local Management for the Environmental Sustainability (European database on the good practices for local sustainability) in order to create a "network" of information exchange among local authorities.

This process, just started, would allow the construction and the continuous updating of a working tool for public administrations, environmental associations, environmental experts, general public and for everyone who needs to know what is going on in the matter of environmental sustainability.

The analysis was conducted for the Italian territory with a focus on the Trasimeno Lake, the response has been excellent, as the proposals came from different areas of interest (academia, government, NGOs, civil society, professionals). The spatial analysis was conducted in both the design and the check phases, where the results were critically analyzed. Moreover, we introduced information layers relating to the main geomorphological parameters of the basins relative to each lake.

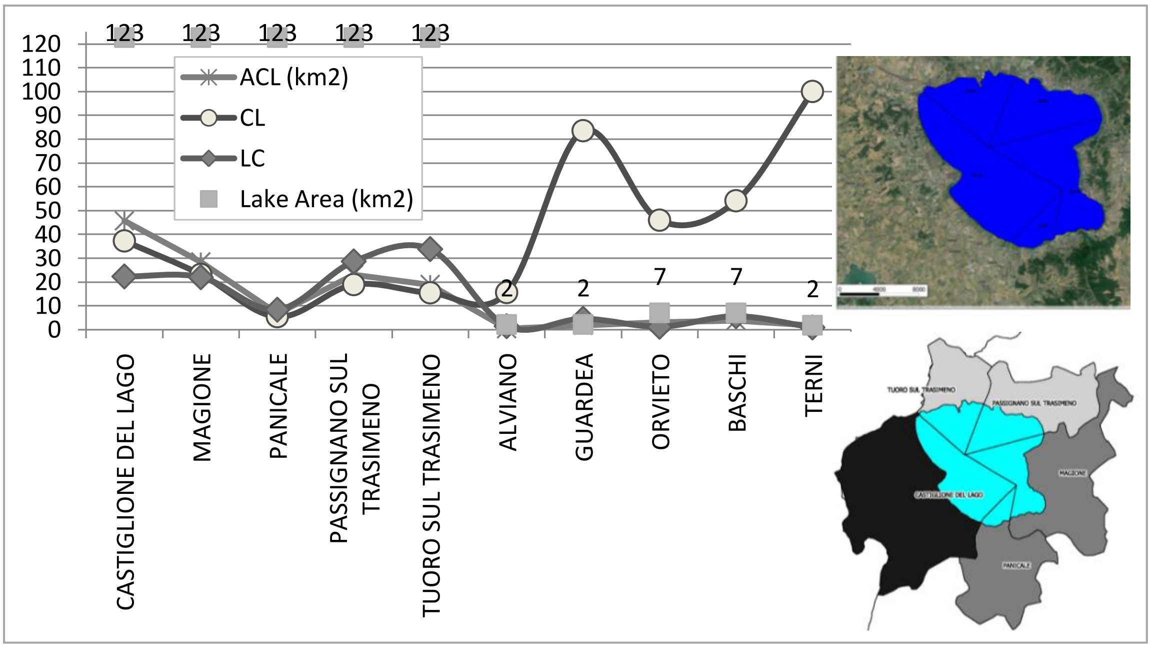

Fig 1. Lakes of Umbria Region (Italy) 1 Municipalities vs Indices (right). GIS analysis for Lake Trasimeno.

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Assessment of water governance for sustainability of Pashan Lake, Pune, Maharashtra, India

J.Sayali & B.i Thorve

Keywords: Pashan Lake, water governance, restoration, public participation, decision-making

Introduction

Distressed status of the lentic-lotic systems due to urban growth with respect to its availability, quality, quantity and ecology impinge on the livelihood of people ultimately. Ecological health of the rivers and lakes which describes the quality of water can be identified by checking Dissolved Oxygen (DO) levels. They are found way below the prescribed limits in most of the urban rivers and laekers. Combined sewerage systems are the largest source of water pollution in all the class I and Class II cities of India[1]. Many water bodies like Yamuna River in Delhi, Mithi in Mumbai, Hooghly River in Kolkata, Mula- Mutha in Pune, Hussensagar Lake in Hyderabad etc are polluted due to discharge of sewage, industrial and solid wastes[2]. Urban tributaries like Ram river have become the carriers of wastewater and converted into nalahs directing it towards the river. One of the victims of the haphazard development is Ramnadi in the city. It is reported that the original width of Ramnadi was 48 m, but now due to increased pressure on land use to over growing population the river width has been reduced to hardly 5- 8 metres at some places. The City Development Plan has deomted Ramnadi from river to drain causing major concern amongst the citizens and environmentalists who have been working for the rivers of Pune for the revival their ecosystems. There has been millions of money spent on cleaning the river corridors, repairing and connecting drainage pipelines and installing new techniques to treat waste water. Unfortunately, the plan lacks in focus and green infrastructure as well as allocation of funds.

Ramnadi River Basin

Ram River is a small watershed which lies between Mula River at the north and Mutha River at the south (fig. 1). It originates at Warpewadi and continues to flow through Bhukum, Bhugao, Bavdhan, Pashan, Someshwarwadi, Aundh and meets Mula near Baner. The total catchment area of Ramnadi River is 50.35 sq km and has an elevation ranging from 550 m to 800 m above mean sea level. The study area receives 590 mm of average annual rainfall in the months of June to September as well as experiences showers in October and November.

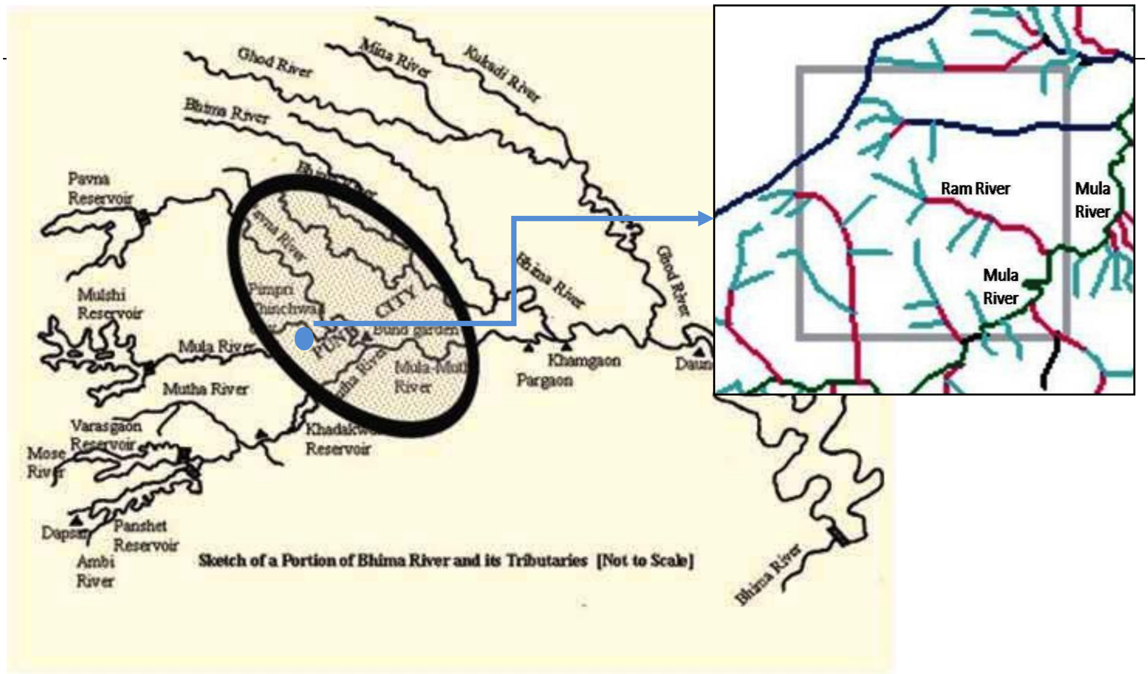

Fig. 1. Basin of Mula river, Pune, Maharashtra State, India and its tributary Ram River[3]

Geomorphologically, Ram river's basin area is made of weathered basaltic rocks over millions of years and it has sloping terrain. In the upland area river course in flanked by high hills. The drainage pattern is mainly dendritic and sub-dendritic involving higher order streams which are seen in the lower reaches of the watershed[4]. Downstream areas with gentle slopes - particularly Bavdhan, Pashan, Aundh and Baner have undergone rapid hydromodifications due to urbanization at a startling speed in the last two decades. Most of the pervious land surfaces have been converted into the impervious one for the purpose of construction and transportation. These landscape alterations have caused flash floods and reduce the storage capacity of aquifers. The area which falls outside jurisdiction of Pune Municipal Corporation is relatively covered by agricultural land and semi ever green type of land which is been purchased and modernised with infrastructures by developers, industrial houses for development (Table no. 1).

Sr. No.	Site	Brief description	Characteristic features
1.	Upstream	Bhukum Village	Crenon and rhithron environment, zero order, first order and second order streams.
2.	Mid-stream	Saikamal Society, Bavdhan	Third order stream, potamon environment, Flood prone area
3.	Down-stream	Someshwar Mandir, Pashan	Third order and fourth order river, potamon environment, highly polluted, Historical site, joins Mula River.

Table 2. Catchment of Ram River

Methodology

Survey of people's interpretation of water governance that are directly or indirectly dependent on Ramnadi River was conducted within river basin to have opinionated view on current situations related to river basin management practices. Ramnadi River basin was divided into three parts; Upstream, Mid-stream and Downstream, to carry out the survey. Sample size was

100 and it involved men and women from different age groups, economic and educational statuses. The questionnaire was in english and Marathi (regional language). This questionnaire on "Study of Water Governance for Ramnadi River Basin" addressed multiple perspectives and, was examined and dissected in very human terms: who should be responsible for Ramnadi River basin Management?; how can institutional capacity improve?; what control measures should be taken to ensure good water quality of Ramnadi?; which actions will you take immediately to maintain the natural quality of river? Overall all the discussions points included the questions of how basin level activities can be managed sustainably for people and environment.

Observations and discussion

Water, like religious faith and principles, is able to move, motivate millions of people. Since the very birth of human civilization, people are settled close to it or moved from scarce area to abundant water area. People everywhere and every day need it, fight over it, write, sing, and dance about it. One must treat water as the most valuable commodity in the world, the most priceless natural resource.

British colonial water law in India in 19th century introduced a concept of government's control over water for maximization of revenue by announcing the rights to regulate water. It emphasized the common law principles for the rights of landowners to access water[5]. Nineteenth century is the considered as a landmark period of legal command over activities responsible for environmental pollution[6], but colonial understanding of hydrology could not come to terms with the peculiar ecological health of Indian rivers, lakes and their basins[7]. Later on after indepedence, Constitution of India was developed in 1950 acknowledging the owership of the people of India and trusteeship of the governments over water resources. "Regulation and development of inter-State rivers and river valleys to the extent to which such regulation and development under the control of the Union is declared by Parliament by law to be expedient in the public interest."[8]

Public participation means different responses in different scenarios in different geo-climatic conditions depending on socio-cultural-occupational aspects. In the countries having heritage of thousands of years like India, participation is more of a significant ethical tool, encouraging the supplier to improve services and to identify the needs of the consumers. While tackling the various issues of water, there is a far-reaching acknowledgment of integrated approaches for water governance. Given the breadth of challenges and inherent role of many organizations and stakeholders, modes of cooperation and coordination have been widely identified in the research literature as being essential for improvement of outcomes[9]. A concerted water planning, sounding and dynamic stakeholder involvement is essential for watershed development in the urban sector. Good water governance builds mass education, awareness and involvement in the stewardship of the rivers and lakes. This approach plays a crucial role in diminishing conflicts and initiates positive changes in river basin.

People surveyed, were reached harmonious notion that Ramnadi river basin management is the responsibility of the city municipal corporation – local self government. According to official documents, only half of the length of river comes under Pune Municipal Corporation jurisdiction, ensuing that river is divided into three authorities – local governance, district governance and state water department. But from the survey, it is clear that very few people are aware of jurisdiction of government stakeholders. This has created an inept approach to the river basin management resulting into Pashan Lake being a receptor of upstream pollution. Neglecting behaviour has increased the pressure on land and water resources at the down streams along with exploitation and reduced availability of water to the vulnerable groups. Majority of the people opinionated that water issues cannot be managed effectively by water controlling institutions alone. Appointing knowledgeable water specialists and a healthy communication between decision makers and stakeholders must be facilitated for capacity building of institutions. Majority of the respondents think that enforcement of current policy / legislations / rules at all governmental layers is crucial but it is not sufficient to maintain ecological health and water quality of Ramnadi River and downstream Pashan Lake. Many respondents stated to upgrade state policies and form link between the national and state action plans ensuring the involvement of key stakeholders.

Some respondents said awareness and education would lead to responsible behaviour and formation of a Lake and River Basin Management Committee. It can bring all the stakeholders together on one platform. While analyzing the views and aspirations of people from the city, the concern about removal and treatment of waste water was explicitly evident with enforcement of laws and regulations to restrain the illegal discharges into the streams of the catchment. The second issue prioritized by respondents was to make policy reforms and amendments in rules and regulations and better implementation on ground.

Conclusion

Rural and urban populations in the catchment of Ram River and Pashan Lake are aware of modernization and hydromodifcation of water resources. They are expressive enough to spell out the concerns for the conservation and protection of water bodies by developing a consultative platform for Integrated Lentic-Lotic Basin Management (ILLBM) for a small part of huge catchment of World Lake Vision Candidate – Ujjani Lake, Pune District, Maharashtra State, India.

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Socio-economic analysis to evolve governance policy for ecological restoration of polluted water bodies with reference to study of polluted river in Ludhiana City, India

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Introduction

Pollution of inland freshwater systems is a global challenge having very complex reflection in socio-economic structure of the upstream-downstream societies. Discharges from the upstream urban and industrial growth not only pollute the surface waters but ground waters also get polluted severely. In era of global warming, changing climatic trends affecting the water availability in the water basins all over the world, it is essential to reform the socio-economic paradigms of development.

Buddha Nallah – a naturally isolated stream of Satluj, this old stream – Buddha nallah is traversing through Ludhiana city. Buddha stream once a water source for villages in vicinity of Ludhiana city till 1960's, has become dumping yard receiving all liquid and solid waste streams from the urban, peri-urban areas of Ludhiana, - the industrial city of Punjab. It is just like any other ordinary (including Capital of India) city in India with sloppy, careless attitude towards maintaining the wholesomeness of urban water bodies. Thus the water of Buddha stream is not suitable for any use and after the confluence the same defiles the Satluj river to such an extent the water is black coloured upto 40 km and it's impact is observed on species of Harike Wetland 80 km downstream. Though having a large water front in vicinity, people from these villages and most part of Ludhiana city are compelled to use ground water for irrigation and domestic use.

"Buddha NEER Project" (Buddha Nallah Ecological and Economic Restoration Project), a first of its kind demonstrative R & D bioremediation project by Government of India[1, 2] has started with the advent of Central Pollution Control Board and Chief Minister of Punjab in the end of July 2010 and supported by then Minister for Environment, Government of India designed by Shrishti Eco-Research Institute (SERI), Pune and being implemented by Green Infrastructure (GRIN), Pune (Green Curator)3.

SESS, SEERAM and SERI's expert team has evaluated the current status and trends of pollution impacts downstream of Ludhiana city. Socio economic and health survey was carried out with aim to realize the impact of this pollution on livelihood and health of community on the banks of Buddha nallah and Satluj River.

Materials and methods

Volunteers from SESS, SEERAM and PAU conducted this survey on the stretch of Buddha stream downstream to Ludhiana city till Harike Lake, which is a Ramsar site, after confluence of Satluj and Buddha stream. During the survey about 75 villages on the both bank of Buddha stream and Satluj River were visited. Total span of the study was about 10 – 12 months inclusive of pre-survey (2 months), survey (1 month) and post-survey data analysis (6 months) plus period required for logistic arrangements.

Fig. 9. Buddha Stream and Satluj River Ludhiana to Harike wetland

While preparing the questionnaire most care was taken to include all the aspects contributing the socio-economic development of those villages. It gives information about the family members, education, source of income, agricultural details, health information, health assessment, community facilities available, etc.

Results

Pollution load

Colour of Buddha stream water becomes darker as it traverses through Ludhiana City after receiving effluent discharges from densely populated areas and imparts colour to Satluj River water after confluence remains upto 40 km downstream.

Estimated pollution load in terms of COD is about 300 – 500 tons/day[4].

Fig. 10. Physical appearance through satellite image at confluence of Buddha Stream with Satluj River

Dissolved Oxygen (DO) of Buddha Stream becomes zero and remains <1 till the confluence with Satluj River. Anaerobicity in Buddha stream gives rise to enormous foul odour in the ambience making it nauseating for the villagers.

Buddha stream hydrologic system contains solvents, toxic carcinogenic chemicals and heavy metals in excess in surface and ground waters. Radioactive Uranium is found to be 100 times that of prescribed standard limit of 0.003mg/L[5]. Concentration of radioactive Uranium is comparatively more in groundwater samples than surface water samples and the same water is being used for drinking purpose. Volatile organics and fecal coliforms are noticed not only in surface waters of Buddha nallah and Satluj River but in groundwater samples also.

Livelihood and health

Interaction with people in those villages evolved the socioeconomic and health issues of the community mostly dependent on ground water due to polluted Buddha stream and Satluj River. Though going through worst situation the humanity shown by the villagers touches hearts as well their concern about the situation was well reflected through their emotions. Many of villagers complained about serious water-borne illnesses.

The villages with ease of transportation facility e.g. Hambran, had both- a better literacy rate and lifestyle. Most people had independent water filters installed in their houses. Fewer people complained of health problems, but lifestyle diseases like hypertension and diabetes were on the rise.

As we progressed towards the interior, the access to the villages became difficult and literacy and basic hygiene levels dropped. Most villages had open drains and were beset by hordes of mosquitoes and flies. In many villages there was no network of water supply, and where the villagers were dependent on water from bores that were shallow the health complaints were more especially of typhoid and jaundice.

Lack of health facilities and proper treatment regimens has led to many people complaining of recurrence, highlighting the fact that there are many, who are carriers of this disease, in this area. The women looked anemic and tired because of malabsorption due to intestinal parasites. Many admitted that their children had parasite infestations and so were not robust in health. Many young women had very dry skin and very dry and fragile hair. The curative steps of a higher water intake were annoyed by them as the water was not palatable. There were many people who complained of having kidney stones, and there were a few who had gall stones. The bone density camps that conducted by DMC and Hambran Hospital in the rural areas, observed a significant rise in the cases of osteoporosis.

Discussion

Studies of socio-economic impacts of constant, uninterrupted dispersal of pollution from point and non-points sources on health and agro-economics is presented with respect to the case study of Ludhiana – the industrial city in Punjab State of India. Pollution control measures are insufficient to tackle the ever-increasing industries and subsequently the population leading to sever contamination of surface water bodies finally ending into Lake Harike – a tail end Ramsar Wetland. Enroute from Ludhiana city to Lake Harike the population and agriculture on the banks of stream receive contaminated water affecting their health and economy. It can be stated that the spreading of contamination through the surface-ground water exchanges has led to various water borne diseases. About 10% of the 40,000 population is suffering from dysentery and various alimentary ailments and 1% of the population is distressed due to cancers. Economically, the downstream rural population is severely facing pollution stress due to degraded quality of crops resulting from use of dirty water. It is recommended that the development policy needs to integrate with goals of attaining regional economic stability commensurate with environmental health and population health.

Environomics (Environmental Economics) of Buddha NEER Project[6]

Cost of treating the severely polluted 600 MLD flow like Buddha Stream by conventional bio-mechanistic systems, the capital expenditure is estimated to USD 99 million (INR 600 cr) with annual operational costs about USD 4.9 million (INR 30 cr) . Buddha NEER's ISEO using green bridge system and maintenance – monitoring of 5 years, the total budget is about USD 3.6 million. (INR 22 Cr)

The focus of ISEO is the process of remedial actions by ecosystem and not the infrastructure. Secondly, the land required for treatment structure is zero being in-stream system and that of conventional system the requirement is at least 200 acres. So, as far as land savings are concerned, there is no match.

Infrastructural STP, ETP or CETP having cumbersome civil and mechanical units are considered to be "assets" having resale value. But there is no such "resale-ability" in case of ISEO being only "process" oriented structures built using locally available materials and consumable bacterial cultures.

It's a repulsive notion as far as financial institutions classical theories of economics. But, the kind of restoration ISEO brings to the water body is far more than conventional engineering and ecological practices. If ecological accounting is included in the projects, then the profit and loss statements will change drastically with inclusion of incremental social, ecological capital and exponential continuous benefits.

As per ecologically corrected water from Buddha NEER Project for agriculture, would be benefited in terms of be about 15000 ha under irrigation. With previous experiences of Udaipur's improved agricultural and fish productions, the benefits are far-reaching as it is the lower strata of poverty stricken masses that enjoy it.

Sustainable management of water bodies is possible when the entire lentic-lotic system is maintained on the basis of ecological technologies, supported by well-stated policies and well-informed institutions, public support and participation, scientific knowledge and uninterrupted finance. (*Ref. Dr. Masahisa Nakamura and Dr. Walter Rast, ILBM Platform Development Process, ILEC, Japan*).

In-stream ecological operation of polluted drains will revive the agro economic and health status of the 40,000 villagers downstream of Ludhiana city.

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Comparative research on the views and knowledge of local residents of central Greece in two wetlands. Smokovos lake case and Metamorfosis marsch in Karditsa's prefecture, Central Greece

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Keywords: *wetlands, lake, environmental knowledge, sex*

Introduction

Wetlands, because of the fact that they are ecosystems, ensure biodiversity while they satisfy many human needs. Several studies emphasize the importance of using local people's views as starting on the design and implementation of appropriate management plans for sustainable development (Keftoyanni, 2010).

Environmental knowledge is defined as the ability of individuals to understand and evaluate the impact of society on the natural environment and to develop positive values and attitudes through knowledge and awareness (Gambro & Switzky, 1996).

In the context of environmental education, environmental literacy refers to the knowledge and awareness of an environmental issue. Also it refers to the positive involvement and attitude of students towards the environment. The high level of environmental literacy reflects the implementation of the effectiveness of environmental education (Leeming et al, 1997, Eagles & Demare, 1999). Tan Geok-Chin Ivy et al (1998) argue that through knowledge and awareness positive values and attitudes are developed. Knowledge is considered as precondition for appropriate action (Hines et al 1986,1987, Engleson & Yockers, 1994).

The purpose of this research is a comparative research on the views and knowledge of local residents in two wetlands, the artificial lake of Smokovos case and the marsh of Metamorfosis in Karditsa's prefecture, based on the sex of the respondents. It is investigated whether sex is associated with the level of general knowledge on wetlands and especially with these two wetlands of study area.

To achieve this purpose a survey was conducted with a sample of 498 adolescent residents of the area in which the above wetland systems belong. The existence of differences in the averages of the levels of knowledge of the sample for the wetland ecosystems in general and for the wetland of their region were investigated as for the sex of the respondents.

The level of knowledge was recorded as low in general and specifically for each wetland, with no statistically significant findings for sex. Teenagers in the wider area of marsh of marsh of Metamorphosis had highest averages in comparison with the averages of the teenagers that live in the wider area of the Smokovos wetland. Boys who live in the surrounding area of

Metamorfosis, have highest averages in relation to girls in their area. The opposite is occurred in the wetland of Smokovos. However, these findings were not statistically confirmed.

Materials and methods

The survey was conducted using structured questionnaires from the spring of 2012 to the spring of 2013. The inhabitants' knowledge on general and local environmental issues concerning wetlands, was recorded and evaluated. It was followed Papapanagou (2006) methodology. Moreover, it was used the same research tool, which was modified where it was required. The data were processed with the statistic program SPSS. Actually, methods of descriptive and inferential statistics were used.

The sample consisted of 498 adolescents from the wider areas of the wetlands that were controlled. The 260 (52.2%) of the respondents were males and 238 (48.8%) were females. As for the wetland of Metamorfosis, there were 293 inhabitants of this region, of whom 153 were males (52.2%) and 140 females (47.6%). In addition, for the wetland of the artificial Lake of Smokovos there were involved 205 inhabitants of the wider area. The 107 (52.2%) of these were males and 98 (47.8%) were females.

The variables that were used in that comparative research were created to measure the knowledge of the inhabitants (Efthimiou et al, 2012, Tagkouli et al, 2014, Papapanagou, 2006). Specifically, the variable W_Gen concerns the knowledge of wetlands in general, the variable W_OWN concerns the knowledge of the area of the wetland and the variable W_TOT concerns the sum of knowledge about wetlands. The variable LMH_W_Gen was created after categorizing the three levels of knowledge (low, medium and high), and it is concerned to the knowledge about wetlands in general. Moreover, there were created two more variables, the on the categories of knowledge about wetlands generally variable the LMH_W_OWN and the LMH_W_TOT which are about the knowledge for the wetland of their region and the knowledge of the wetlands in general, after the same categorization. Then, the averages of each variable were compared by region and sex.

Results

VARIABLE	SEX	(a) Mean Meta-morfosi	(b) Mean Smokovos	(a)-(b)	Metamorfosi: Mean MALE-Mean FEMALE	Smokovos: Mean MALE-Mean FEMALE
W_Gen	M	7,00	6,43	0,57	0,22	-0,23
	F	6,78	6,66	0,12		
W_OWN	M	6,87	6,03	0,84	0,13	-0,03
	F	6,73	6,06	0,67		
W_TOT	M	13,70	12,35	1,35	0,32	-0,31
	F	13,38	12,65	0,72		
LMH_W_Gen	M	1,79	1,73	0,06	-0,03	-0,02
	F	1,82	1,74	0,08		
LMH_W_OWN	M	1,98	1,85	0,13	0,02	0,04
	F	1,96	1,81	0,15		
LMH_W_TOT	M	1,89	1,79	0,10	-0,02	-0,05
	F	1,91	1,85	0,06		

Table 1. Mean difference by Sex

Differences in the level of knowledge of individual variables of the adolescents in our sample, as for the sex were occurred and presented in Table 1. The teenagers of Metamorfosis area, have higher average of knowledge in addition to the teenagers of Smokovos area, in all individual variables and the overall one, as it is occurred by the differences on the averages. Regarding sex on the area of Metamorfosis the level of knowledge of males are higher than females on W_Gen, W_OWN, W_TOT and LMH_W_OWN variables, while for the variables LMH_W_Gen and LMH_W_TOT the level of knowledge for females is higher than males.

Analyzing Smokovos area the level of knowledge of the females is higher than males for the W_Gen, W_OWN, W_TOT, LMH_W_Gen, LMH_W_OWN variables, while the level of knowledge of males is higher than females for the LMH_W_OWN variable. As for Metamorfosis area, the level of knowledge of males is higher than females, whereas the opposite is occurred on Smokovos area where the level of knowledge of females is higher than males. These differences in averages are not statistically confirmed.

Discussion

These results agree with those of Efthimiou et al. 2012, Tagkouli et al. 2014). The fact that most of the respondents know a little about the wetlands of their region is very distinctive, as it is cited on the previously mentioned researches. To improve the level of knowledge is required more well organized information, events, integration on environmental educational activities egration on environmental educational activities and creation of infrastructures for attendance to audience and finally, improvement of the level of knowledge of the researched areas is needed.

Further research on wetlands so as to identify and confirm these results by use of several methods and qualitative research is also needed. The results of this research, can be used for further development of environmental programs regarding to environmental education to all levels of education (Ntouras, 2013). It is desirable to pursue development of positive environmental initiatives by the local community that will lead to the development and enhancement of environmentally friendly attitudes.

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Water analysis of Godawari river (Dhangar Takali to Vishnupuri Dam), Maharashtra, India

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Keywords: River water quality, Jal Dindi, Awareness, Sarovar Samvardhini

Introduction

The Godawari River is one of the major rivers of India. It originates at Nashik in Sahyadri ranges of Maharashtra and meets the Bay of Bengal at Rajmundri of Andhra Pradesh traveling a distance of 1465 km. Its catchment area is 312812 km^2 with 48.6% coverage in Maharashtra and 23.4% coverage in Andhra Pradesh. It is located between $73^0 24'$ to $83^0 4'$E and $16^0 19'$ to $22^0 34'$N. The holy Godawari river is shrinking due to sand mining, sedimentation of dams, industrial and domestic pollution (industrial 18%, domestic 82%). There is not even minimum environmental flow maintained in the river at many stretches. (Shinde and Waikar, 2007). Hydrology Project is being implemented by Government of Maharashtra with the assistance of World Bank with its head office for Maharashtra at Nashik, for the monitoring water quality in the river. There are 75 hydrological observation stations and 42 water quality monitoring stations in Godavari basin (Figure 1). SWEDES and HYMOS software are used for data entry and analysis. Further for the purpose of close monitoring of given reservoir/lake, a concept called Sarovar Samvardhini as an organization of stakeholders dependent on the lake system has been developed in India. It was initiated with Global Water Partnership under the thematic network of Lakes and Reservoirs. Indian Association of Aquatic Biologists (IAAB) is the driving agency for this theme in India.

Shankar Sagar Sarovar Samvardhini

The Ministry of environment and Forest (MOEF), Govt. of India, has issued guidelines for management of lakes and tentative actions are suggested. It envisages a comprehensive and holistic approach for lake conservation. The socioeconomic development of the people dependent on the lake is also fully integrated in the plan. It covers:

1. prevention of pollution,
2. catchment area treatment,
3. desilting and weed control and
4. research and development studies.

In line with this and as a part of Global Water Partnership's initiative to establish a thematic network on water quality of lakes in South Asia, Shankar Sagar Sarovar Samvardhini was formed in 2005 around the manmade lake, Shankar Sagar an irrigation project at Nanded, in Godavari basin. It has started its activities with a workshop attended by 70 people from government departments, students of engineering/science colleges, faculty, professional engineers, farmers, fishermen, aquatic biologists, and NGOs connected with river cleaning activity. The activities of Sarovar Samvardhini were conducted as per the guidelines of MOEF for creating awareness, conducting research work and peoples mobilization (Kulkarni and Waikar, 2012).

International Seminar at Yashwant College, Nanded on River Water Quality in 2007 and the technical sessions at SGGS Institute of Engineering and Technology, Nanded on Jal Dindi in 2011 were organized. Consequent upon this, Goda Jal Dindi has been started as a regular activity in Shankar Sagar lake and was successfully conducted in 2012, 2013, and 2014 for three days. It is an activity performed with engineering/science students and faculty travelling in boat in Shankar Sagar lake with following objectives:

a) To create awareness among the stakeholders and students of schools around the lake about conservation and protection
b) To monitor water quality of the lake on annual basis
c) To conduct research in the academic institutes on various aspects of the lake
d) To train Jal Mitra (friends of river) to protect the sources of water from pollution

Materials and methods

The river water samples were collected at left and right bank and middle of the river to study the physical and chemical variation across and along the Shankar Sagar lake for a stretch of 40 km shown in Figure 1. Water samples were collected at regular interval of 1 km with one liter capacity plastic containers. Dissolved oxygen was measured by portable D.O. meter (Hach model). Calcium, Total hardness, Alkalinity, Chloride were determined by titration method and the remaining parameters were determined by Systronics Water Analyser. Water Quality Index was calculated and used to determine the health status of Godawari River (Shinde and Waikar, 2008) for the area studied.

The journey in the lake (Goda Jal Dindi) was performed with the help of professional organizations, academic institutes (three) and administrative departments for three days.

Results and Discussion

Results of samples collected at 45 locations were averaged and presented in Table 1 along with minimum and maximum values. The variations of parameters in which significant variations were observed were plotted in Figure 2. The pH varied from 8.21 to 8.88 with average of 8.534 which indicated the impact of bank erosion. Low turbidity values have been observed in the range of 1.02 to 2.6 NTU. The TDS varied from 320 to 720 ppm with average of 362.8 ppm. Higher values were observed near the villages indicating impact of occupational activities. However it is in the acceptable range as the desirable limit for drinking water (BIS TDS: 500ppm) but can be accepted in the absence of alternate source. The Total Alkalinity of river water varied from 120 to 250 ppm with average TA of 209.11ppm. The conductivity varied from 200 to 519 micromhos/cm with average of 379.6. The Ca, Mg and Chloride values were observed in the range from 20.048 to 264.52 ppm with average of 98.65 ppm, from 0.86 to 62.69ppm with average of 29.22 ppm and from 29.75 to 209.5 ppm with average of 90.81 ppm respectively. Higher values of Ca, Mg, Chloride and Total alkalinity were observed near the villages. The DO values were observed to be favorable for fishing activity as it was around

9ppm. The total hardness varied from 120 to 300 ppm which was less than the BIS desirable limit for drinking water (500 ppm).

	pH	TDS	EC	D O	Turbidity	Ca	TH	Mg $(CaCO^3)$	Cl	TA	Mg
Avg	8.53	362.8	379.6	10	1.42	98.65	218.04	119.75	90.81	209.10	29.22
Max	8.88	720	519	12.6	2.6	264.53	300	256.95	205.90	250	62.70
Min	8.21	320	200	7.65	1.02	20.05	120	3.53	29.74	120	0.86

Table 1. Chemical Analysis of Godawari River (Shankar Sagar lake) from Dhangar Takali to Vishnupuri

As an outcome of Goda Jal Dindi in Shankar Sagar, 150 students and faculty have participated in last three years to conduct water analysis of the lake and conducted awareness programmes in the schools and villages by interacting with more than 1000 students and 500 villagers. The water quality indices were found to be decreasing very steeply from Gangapur Dam station to Nasik and critical at Nasik, Kopargaon, Toka, Pategaon and Wadvali (locations upstream of Dhangar Takali shown in Figure 1) for all seasons and years as WQI values were less than 0.3. The strong seasonal variation of WQI at all sampling stations was noticed. The monthly, seasonal and yearly WQI were showing decreasing linear trend (Shinde & Waikar 2007). Compared to this, the water quality of the lake was better and free from pollution. The higher values of certain parameters near the villages were a matter of concern which can be tackled during Goda Jal Dindi.

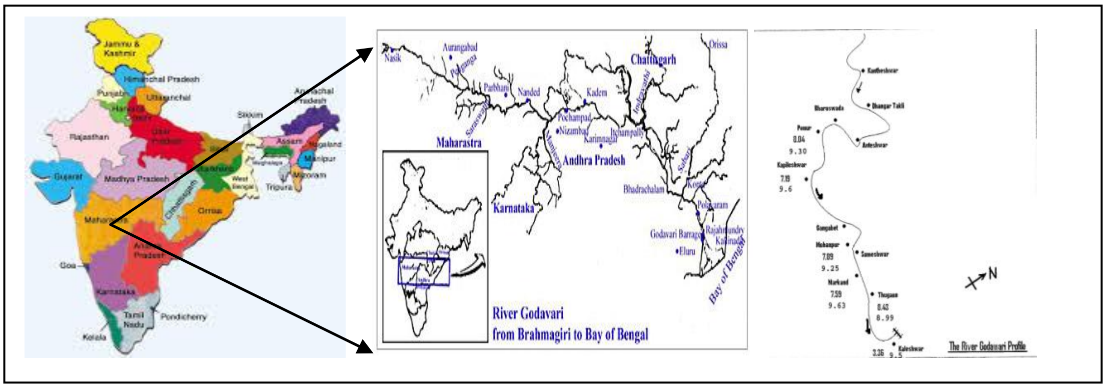
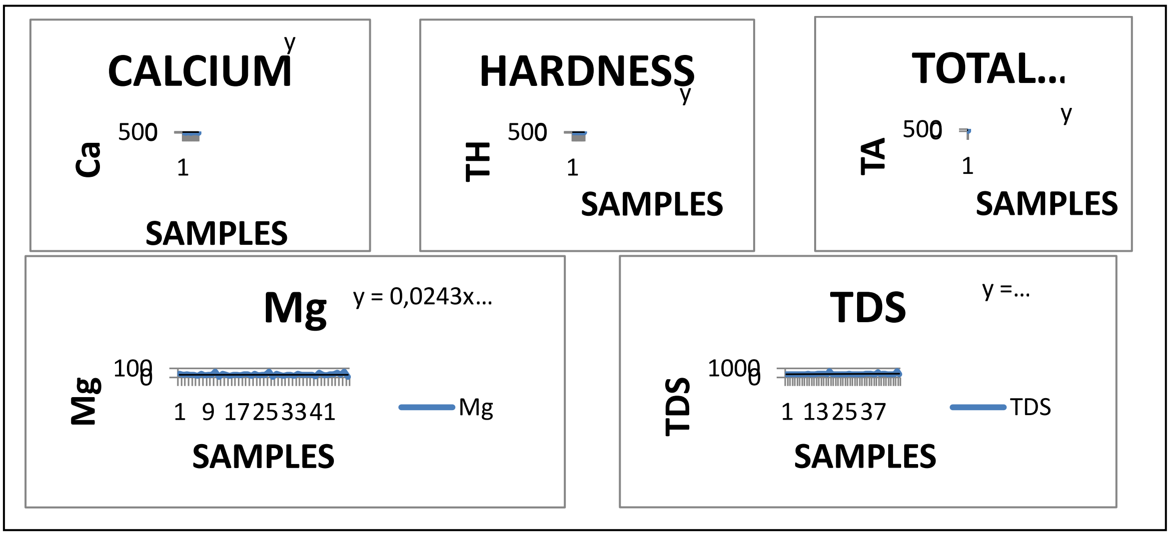


Fig. 1: Location map of the study area



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The Legal Framework

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Keywords: transboundary lakes, water conventions, international environmental law, general principles, sustainable development.

Introduction

Lakes are not isolated water bodies, but are affected by, and themselves affect, a range of upstream and downstream water systems, thus their management is strongly linked to sustainable development. Indeed, concern for conservation of lake waters and natural resources is not a recent achievement, as demonstrated by some ancient documents, among which a manuscript from the 15th Century that codified a complex set of rules on fishing, navigation and other economic activities regarding the Trasimeno Lake, the water basin near Perugia (in Central Italy), the town which hosted the 15 WLC.

So far, over 500 multilateral, norm-creating treaties on several issues concerning environmental protection have been initiated, drafted, negotiated and adopted within or under the auspices of the UN, as well as a long series of non-binding instruments, such as declarations, recommendations and resolutions (the so called '*soft law*'). Most of the times, the rules are new when the treaty is first formulated, then they become binding once it is ratified by a considerable number of States or even before that, in case they can be considered reproductive of customary law. Many of those rules are also applicable to transboundary lake management. The aim of this paper is to give a general overview on such rules.

***Fig1**: Lake Trasimeno (Alinari's Archive, Florence 1890)*

Materials and Method

The ongoing treaty-law making process on issues related to the assessment and protection of water resources testifies a long evolution that lead to the dismantlement of absolute sovereignty claims over water resources by the territorial State ("absolute sovereignty doctrine", epitomized by the Harmon doctrine), in favour of a sustainable use of freshwaters so as to meet a common interest ("absolute territorial integrity doctrine").

Although many uncertainties linger on the scope of International norms applicable to this sector, due to the fact that the provisions enshrined in existing multilateral instruments have a different nature and legal status, in several occasions International judges and arbitrators acknowledged the existence of some important general principles of International Environmental Law (IEL) that are applicable to disputes concerning the exploitation of hydrological basin, even in the absence of any specific consent by the States concerned (www.internationalwaterlaw.org/cases/icj.html). Two seminal judgments can be mentioned here in which the International Court of Justice, the main UN judicial body, dwelt upon the formulation, content and applicability of general principles of IEL to disputes related to the use of freshwaters: the Case of the *Gabcikovo-Nagymaros Dam Project*, (Slovakia v. Hungary, 25 September 1997) and the *Pulp Mills Case* (Argentina v. Uruguay, 20 April 2010). In both situations, besides the specific bilateral treaties applicable to the specific case, the Court, in its attempt to reconcile the diverse interests over matters of transboundary water management, evaluated the applicability of principles such as: “equitable and reasonable utilization”, according to which utilization of water is not considered to be equitable and reasonable if the interests of the other riparian State in the shared resource and the environmental protection of the latter are not taken into account; the “no harm rule”, that incorporates the concept that a State shall use waters in its territory in a manner that does not cause appreciable harm to other riparian States, efficiently expressed in the Roman maxim: *sic utere suo ut alienum non laedas,* which states that entitlement to a right corresponding to a legal obligation involves the obligation that such a right is not abused by his holder; the *principle of cooperation*, as well as that of prevention, which has its origin in the due diligence required of a State in its territory and is connected to the duty to avoid significant prejudice to other users. Another general principle the existence of which is still disputed imposes the duty to *carry out an environmental impact assessment* before initiating industrial activity, where there is a risk that the proposed industrial activity may have a significant adverse impact in a transboundary context on a shared resource.

Nonetheless, the above described general principles of International environmental law *per se* are not sufficient to establish an effective and efficient regulation of all the activities regarding a transboundary lake. Treaty law is of course the best way to embody and further specify the said principles in order to reconcile the diverse interests at stake. To this extent, a successful instrument is the 1992 Convention on the Protection and Use of Transboundary Watercourses and International Lakes, negotiated among UNECE Member States. It is a framework agreement in force since 1996 among many European States that fosters the implementation of integrated water resources management, in particular the basin approach, requiring State Parties to prevent, control and reduce transboundary impact, and to use transboundary waters in a reasonable and equitable way so to ensure their sustainable management. In this respect its implementation contributes to the achievement of the *Millennium Development Goals* and other international commitments. The same logic applies to the 1997 Convention on the Non-Navigational Uses of International Watercourses (UN Water Convention), just entered into force (14 August 2014) for 35 States, and also to the Draft articles on “The law of transboundary aquifers” adopted by the International Law Commission in 2008, which will be discussed by the UN General Assembly in its 71st session.

As a matter of fact, effective lake management and governance requires consideration not only of the relevant International rules dealing with freshwaters, but also of other norms whose respect or disrespect can have an impact on a whole lake basin and which, therefore, do form part of the legal framework of lakes. This is particularly the case of the Multilateral Environmental Agreements on biodiversity-related issues (MEAs) promoted by the UN system, such as the Convention on Biological Diversity (1992), the Convention on the Conservation of Migratory Species (1978), as well as the Ramsar Convention on Wetlands of International Importance (1971), which remains, however, outside the UN system of MEAs.
Lastly, as far as the preservation of natural landscape is concerned, we cannot forget the opportunity to enhance the conservation of lake basins offered by the 1972 UNESCO Convention on the protection of the World Cultural and Natural Heritage, by means of their inscription in the World Heritage List as part of the World Natural Heritage.

Results

The analysis of International law and State practice demonstrates the existence of a cluster of general rules of International Law, binding on all States, that provide the basic legal framework for a sound lake regulation. This legal systems lays on a three-pronged pillar built on the basis of a few principles: equitable utilization, no-harm rule and cooperation, which are mutually interdependent and involve some kind of self-imposed constraint on State sovereignty for the pursuit of the common interest related to environmental protection and equitable water allocation. Around those principles new norms and standards have been set forth in a great number of instruments over the last decades, which have further developed the legal framework. Consequently, “such norms have to be taken into consideration, and such new standards given proper weight, not only when States contemplate new activities but also when continuing with activities begun in the past. This need to reconcile economic development with protection of the environment is aptly expressed in the concept of sustainable development” (ICJ, Gabcikovo-Nagymaros Case, 1997).
In conclusion, non compliance by States with the rules forming part of the legal framework applicable to lakes, such as those briefly outlined above, constitutes damage to the common interest and does not guarantee an equitable utilization by all actors involved.

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The role of biodiversity-related meas: providing another layer of international legal protection to lakes and their natural resources?

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Keywords: biodiversity; multilateral environmental agreements, CBD; protected areas; lakes.

Introduction

Multilateral environmental agreements on biodiversity-related issues (biodiversity-related MEAs) entail a whole set of international law rules on the protection, conservation and sustainable use of natural living resources (as species, natural habitats and ecosystems). The maintenance and management of said resources, worth of international legal protection under these agreements either for their 'outstanding universal value', their being a 'common heritage' or constituting a transboundary issue engendering a 'common concern', is typically demanded to national authorities in turn responsible for the realization of administrative arrangements in this respect as, for instance, the creation of protected areas.

Three Conventions on wildlife and habitat protection for more than four decades have been functioning as the main international legal instruments in this regard (the 1971 Convention on Wetlands of International Importance especially as Waterfowl Habitats, the 1972 Convention concerning the Protection of the World Cultural and Natural Heritage and the 1978 Convention on the Conservation of Migratory Species). Each of them contains rules providing for the creation of protected sites, to be implemented with the view to realize a strict regime of protection (at local level) that is supported by initiatives variously undertaken by each COP (at international level). The 1992 United Nations Convention on Biological Diversity (CBD), a global treaty with an overarching scope embracing all biodiversity issues, at the same time superseded and supported the functioning of its sectoral 'predecessors'. This is because as the other biodiversity-related MEAs, the CBD contemplates the realization of protected areas as a means for *in situ* conservation (article 8, paragraphs a) to e)) and is equipped with a more sophisticated system of governance.

The study at hand comprises a brief and preliminary overview of the substantive provisions enshrined by each MEAs on the designation of protected sites. This analysis will be instrumental to answer a number of questions. Firstly, it will be seen whether and to what extent said provisions are implemented in order to provide effective legal protection to lacustrine biodiversity and lake ecosystems. Secondly, an attempt will be made to see if and to what extent the rules on designation of protected areas supplement extant systems of international legal protection introducted by virtue of other legal instruments as, chiefly, the 1992 UNECE Convention on the Protection and Use of Transboundary Watercourses and International Lakes (UNECE Water Convention).

Hence, attention will be devoted to an assessment of the practice being developed by the Conferences of the Parties (COPs) under each biodiversity-related MEA. More precisely, the aim will be to see if and how decisions supportive to the effective legal protection of lacustrine biodiversity and lake ecosystems are actually adopted, starting from decisions on, and initiatives relating to, the designation and maintenance of lake protected areas.
The overall objective of this paper is to see how and to what extent the designation of lake protected areas pursuant to biodiversity-related MEAs is capable of reconciling the exercise of State sovereignty and the global interests attached to the protection of the Earth's lakes while discouraging the indiscriminate grabbing of lacustrine natural resources.

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The contribution of the UNECE Water Convention to the prevention and resolution of transboundary water disputes

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Keywords: UNECE Water Convention; international water law; Implementation Committee; dispute prevention and resolution

Introduction

While international water law as a whole can be said to enhance the functioning of dispute avoidance and settlement on the use of international watercourses, the purpose of the presentation is to address specifically the contribution of the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (1992 UNECE Water Convention) to the prevention and resolution of transboundary water disputes. Attention will be paid to the recently established Implementation Committee of the UNECE Water Convention as well as to the various means and procedures foreseen under this Convention. It will be argued that the role of the Implementation Committee, the provision on dispute settlement, together with the procedural obligations on cooperation, provide an effective framework for the prevention, management and settlement of water disputes.

Discussion

The Convention on the Protection and Use of Transboundary Watercourses and International Lakes 1992 (hereafter 'UNECE Water Convention'), which was negotiated in the framework of the United Nations Economic Commission for Europe (UNECE) (Tanzi, 2013), was adopted on 17 March 1992 in Helsinki and entered into force on 6 October 1996. The purpose of the UNECE Water Convention is to prevent, control and reduce the transboundary impact with respect to tranboundary watercourses and international lakes. Being a framework Convention, it establishes some basic substantive and procedural obligations, while it allows the Riparian States to complement them in agreements, which are able to take into account the specific characteristics of the transboundary water resources in question, such as their hydrogeological features, and States technological, financial or administrative capacity.

The normative content of the Convention is based on three pillars: the no-harm rule, the reasonable and equitable utilization, and the principle of cooperation; while in line with other Multilateral Environmental Agreements, the Convention also refers to other principles aiming at environmental protection, such as the precautionary principle, the polluter-pays-principle, integrated water management, and intergenerational equity.

As for the first of the two substantive principles, that is, the no-harm rule, the core obligation of the Convention is the duty to 'prevent, control and reduce any transboundary impact' (article 2, par. 1). As the Parties are required to 'take all appropriate measures' when achieving such an objective, the no-harm principle expresses a due diligence obligation. Among the appropriate measures to be taken in order to prevent, control and reduce any impact, the

UNECE Water Convention obliges the Parties '[t]o ensure that transboundary waters are used in a reasonable and equitable way, taking into particular account their transboundary character, in the case of activities which cause or are likely to cause transboundary impact' (art. 2, par. 2, let. c). The two principles of no-harm and reasonable and equitable utilization are, therefore, 'indivisibly intertwined' (Tanzi, forthcoming).

Under the UNECE Water Convention, the principle of cooperation and its procedural applications deserve special attention. Thanks to its mandatory and detailed nature, the principle of cooperation provides the distinguishing feature of this Convention from other international water law instruments, and fosters dispute prevention and settlement among Riparian States. The first essential obligation for Riparian Parties is to enter into bilateral or multilateral agreements, or other arrangements, in order to define their mutual relations and conduct regarding the prevention, control and reduction of transboundary water impacts (article 9, para. 1), whose content should consist of three elements: first, 'the Riparian Parties shall specify the catchment area, or part(s) thereof, subject to cooperation'; secondly, '[t]hese agreements or arrangements shall embrace relevant issues covered by this Convention, as well as any other issues on which the Riparian Parties may deem it necessary to cooperate'; thirdly and most importantly, such agreements or other arrangements 'shall provide for the establishment of joint bodies' (Guide to Implementing the Water Convention, 2013). Under the Convention, such joint bodies represent the main institutional channel of cooperation between the Riparian Parties, as they are called to perform several tasks related to the management, control and harm prevention of transboundary water resources. Moreover, further specifications of the principle of cooperation are the establishment and implementation of 'joint programmes for monitoring the conditions of transboundary waters, including floods and ice drifts, as well as transboundary impact' (article 11), common research and development activities for water-quality objectives (article 12), the exchange of available data and information (article 13), including critical situations that may have transboundary impact, and where appropriate, the setting up of warning and alarm systems (article 14), as well as providing mutual assistance (article 15).

The UNECE Water Convention contains a specific provision on dispute settlement (article 22), which refers to the 'solution by negotiation or by any other means of dispute settlement acceptable to the parties to the dispute', and foresees an "opt-in" formula, where a Party may declare in writing to accept as compulsory the jurisdiction of the International Court of Justice or of an arbitral tribunal with regard to disputes that could not be settled by negotiation and in relation to States that have likewise opted in. Although one may notice that this provision does not explicitly refer to various forms of third-party dispute settlement, such as good offices, enquiry, mediation or conciliation, it is the obligation to establish joint bodies for bilateral and multilateral co-operation referred to above, whose tasks cover the widest range of prevention and joint management measures, that displays a direct impact on dispute avoidance and resolution (Tanzi & Contartese, forthcoming).

Through the Implementation Committee of the UNECE Water Convention, established in 2012 at the Sixth Session of the Meeting of the Parties (MOP) to the Convention, the Contracting Parties have been given a further means to deal with non-compliance by Convention States (Lammers, 2014). The Implementation Committee, whose mechanism is described as 'simple, non-confrontational, non-adversarial, transparent, supportive and cooperative in nature, building on the distinctive collaborative spirit of the Convention', is vested with a relatively wide spectrum of tasks geared towards supporting the implementation of and compliance with the Convention (UN Doc. ECE/MP.WAT/2012/L.4, Appendix I). In particular, through the Party to Party mechanism, a State Party is afforded an alternative to adjudication which may combine the features of mediation, conciliation, or simple advisory assistance with the aim to assist the country whose measures affect other Riparian States. In such a case, the allegedly affected country, which is to inform the Party whose implementation and/or compliance is in question before bringing its submission to the Committee, as well as the other Riparian State involved, is required to submit information concerning the difficulty in question to the secretariat, which will transmit the dossier to the Committee. The Committee has the power to decide several measures, and furthermore, '[u]pon consideration of the report and of any recommendations by [the Committee]', the MOP can decide measures, which vary from suggesting assistance to the concerned State(s) to the issuing of a statement of concern, a declaration of non-compliance, or even the suspension of the special rights and privileges accorded to the Party concerned under the Convention.

Conclusion

The presentation has emphasized the role that different provisions under the UNECE Water Convention play in strengthening both the prevention and resolution of transboundary water disputes. Having regard to the principle of cooperation, the UNECE Water Convention establishes stringent obligations, *inter alia*, on setting up joint bodies, which prevent potential conflicts among Riparian States being in charge of several tasks concerning water management measures, while the Implementation Committee provides a means for dispute prevention as well as an alternative tool to the provision of article 22 for dispute settlement.

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LAKE BASIN BEST MANAGEMENT PRACTICES

Identification and classification of artificial and heavily modified lakes in Italy

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Keywords: heavily modified water bodies, artificial water bodies, water uses, mitigation measures

Introduction

This paper summarizes the current state of play with respect to the assessment of the criteria for the identification and the classification of artificial and heavily modified lakes in Italy in the context of the implementation of the Water Framework Directive (WFD: EC, 2000). The Directive, which establishes a framework for the protection of all water bodies and, overall, aims at achieving "*good ecological status*" (GES) for all waters by 2015. In accordance with article 4(3), the WFD provides that for certain water bodies, under specific circumstances, the environmental objective is to achieve the "*good ecological potential*" (GEP) rather than the GES. This is the case of the artificial water bodies and of those water bodies which have been physically altered by human activities (i.e. the "specified uses" such as, e.g., water supply of lakes/reservoirs). These water bodies may be designated as "artificial" (AWB) or "heavily modified" (HMWB), reconciling thus the socio-economic activities and the environmental objectives. The assumption is that the structure and functioning of biological communities of the aquatic ecosystems of HMWB and AWB are different from those of "natural" water bodies because of physical alterations or artificial characteristics due to water uses.

Materials and methods

Technical criteria for the identification and designation of rivers and lakes as HMWB or AWB are established, for Italy, in the Ministerial Regulation of november 27 th 2013, n.156 (Ministry of Environment and Protection of Land and Sea, 2013). The Regulation was necessary to fully implement the provisions of Article 4, paragraph 3, of the Directive 2000/60/EC as transposed in Article 77, paragraph 5, of the Legislative Decree n. 152/06 (Italy, 2006), which gives legal regulations for the identification and designation of those water bodies. The Decree, set up with the assistance of the National Institutes of Science (ISPRA and CNR-ISE), makes also the appropriate changes necessary to conform to Annex 3 of Part III of 152/06 the technical requirements of Directive 2000/60/EC and contains the main output of the Guidelines issued by the European Commission on the subject (Common Implementation Strategy, 2003), defining a coherent national methodology for the identification of AWB and HMWB.
Good ecological potential is defined in the Annex V 1.2.5 of the Water Framework Directive as an ecological state in which *"there are slight changes in the values of the relevant biological quality elements as compared to the values found at maximum ecological potential (MEP)"*. The values for the biological quality elements according to MEP should reflect, "*as far as possible, those associated with the closest comparable surface water body type, given the physical conditions which result from the artificial or heavily modified characteristics of the*

water body". The definition recognizes that the MEP biological values (a) depend on the MEP hydromorphological conditions and (b) may be different from those of any natural surface water body type because no such natural type is completely comparable.

The Directive defines the MEP hydromorphological conditions as those "*consistent with the only impacts on the surface water body being those resulting from the artificial or heavily modified characteristics of the water body once all mitigation measures have been taken to ensure the best approximation to ecological continuum, in particular with respect to migration of fauna and appropriate spawning and breeding grounds*". The mitigation measures referred in the definition of MEP hydromorphological conditions are limited to those that would not have a significant adverse effect on (a) the wider environment or (b) the use or uses that are dependent on the modified characteristics. The purpose of designation of a water body as a HMWB or AWB would be defeated if mitigation measures that would have such adverse effects were included.

This also means that GEP cannot represent a state that could only be achieved using measures that would have a significant adverse effect on the wider environment or on the use or uses justifying designation in accordance with Article 4.3 of the WFD. GEP therefore represents a state in which the ecological potential of a water body is falling only slightly short of the maximum it could achieve without significant adverse effects on the wider environment or on the relevant water use or uses. An assessment of disproportionate costs of the mitigation measures should not be considered.

Results and Discussion

The biological assessment methods sensitive to hydromorphological alterations, related to lakes and also rivers, are at the moment under development. Considering the complexity of the definition of the 'good ecological potential' (GEP), already arisen in several discussion at EU level, the Ministry has established a working group to collaborate with scientific institutes in order to refine a methodology to derive GEP for lacustrine and river water bodies designed as HMWBs or AWBs. In this context a draft document reporting a list of mitigation measures to be applied in all AWBs and HMWBs has been compiled. It is foreseen that this activity will be completed on time for its use in the next River Basin Management Plans.

The document reports the two methods described under the Common Implementation Strategy (common strategy developed by the EU Member States and the European Commission for supporting the implementation of the Directive2000/60/EC, "*establishing a framework for Community action in the field of water policy*") for defining good ecological potential. The original method is described in Guidance n. 4 on heavily modified water bodies (Common Implementation Strategy, 2003). An alternative method is described in the technical paper prepared by the drafting group on hydromorphology and published in 2005 (sometimes called the "Prague method" or the "mitigation measures method": Kampa & Kranz, 2005).

Figure 1 summarizes the main steps involved in the alternative approach to defining GEP (left side of Figure) and compares this with the main steps in the approach set out in CIS Guidance Document No. 4 (right side of Figure).

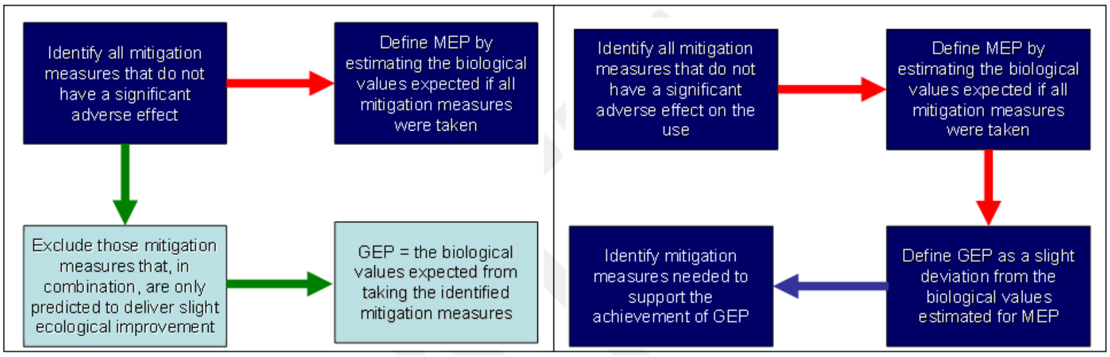

Fig. 1. Steps involved in defining GEP using alternative approach (left side) compared to the relevant steps in the approach described in CIS Guidance Document No. 4 (right side); red arrows: steps following CIS method, green arrows: modifications of CIS method (from: Kampa & Kranz, 2005)

The first step of the alternative approach is similar to that of the approach in CIS Guidance Document No. 4. All mitigation measures are identified that would (a) deliver ecological improvements; (b) not have a significant adverse effect on the wider environment; and (c) not have a significant adverse impact on a water use that relies on the heavily modified or artificial characteristics.

As the first step of both approaches is similar, the document prepared by the Italian Ministry proposes a first list of mitigation measures for specified water use.

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Enhancement of quality of fish product of Trasimeno Lake: PSR UMBRIA project

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Keywords: Biodiversity, fish products, food quality, cold chain

Introduction

Trasimeno Lake is considered a high value ecosystem due to its wide biodiversity. Today, fishing is still one of the main commercial activities of the area. Owing to the introduction of exotic species, profound changes have occurred in the composition of the fish community. The new species such as *Carassius auratus* (Gold fish) have adapted well, while the indigenous species such as tench, carp, pike and eel, have declined in abundance over the years .

The Regional Fund PSR Umbria 2007-2013 (Cooperation for the development of innovative products, processes and technologies for agricultural, food and forest service) is supporting a R&D project related to the Lake Trasimeno in order to: enhance the knowledge of its fish fauna, prepare plans for the preservation of the ecosystem and to find solutions to reduce the number of goldfish and simultaneously benefit the local fishermen's yearly income. Processing raw goldfish fillets could be a solution to the problem, as they can be easily transformed into more attractive.

Freshwater fish is an important source of essential fatty acids for human nutrition. The aim of this study was to study a new process to exploit the abundance of this species to obtain a new fish product with high nutritional quality for consumers, using local aromatic herb and high quality olive oil.

Fish products spoil in relatively short time and temperature variations may cause a potential hazard for the consumer. Application of an optimized quality and safety assurance system for chilled distribution of fresh fish products requires continuous monitoring and control of storage conditions from production to consumption.

In the last decade, the incidence of food borne disease has increased in Europe, despite the introduction of Practice and Hazard Analysis of Critical Control Point (HACCP) and the proliferation of food safety regulations.–Another goal of the project was to allow innovative tests to monitor the cold chain such as time temperature indicator labels.

These systems are user friendly and allow to verify if the temperature of the product has exceeded the correct storage value.

Fish processing technology

Fish caught in Trasimeno Lake was scaled and cut in fillet. The fillets where grinded two times because fishbone are dangerous and Gold fish has many thorns. That is why they were turned into hamburgers.

Hamburger 150 g weight were produced by adding instant mashed potatoes, parsley, chives, salt and pepper. The product was frozen in a blast chiller and keep at -18°C temperature below. The production is carried out in a CE stamp laboratory for processing of fish products.

Chemical analysis of hamburger

Fatty acids contents were determined by gas chromatography after lipid extraction according to the Folch et al. (1957) method. The transmethylation was performed according to the procedure of Ward (2002) The analysis were carried out using a Perkin-Elmer AutoSystem-XL gas chromatograph equipped with a CP-Select CB for FAME fused silica capillary column (100 m x 0.25 mm i.d., film thickness 0.39 µm, J&W, Agilent technologies, Palo Alto, CA, US) and with a flame ionization detector (FID). Individual fatty acid methyl esters were identified by comparison with a standard mixture containing 37 FAMEs (Supelco, Bellefonte PA, USA). The quantitative levels of the main fatty acid groups of the three different hamburgers are reported in Table 1.

	Goldfish hamburger	**Carp hamburger**	**Nile Perch commercial hamburger**
SFA	**37,23**[a]±0.02	**31,10**[b]±0.04	**12,70**[c]±0.06
MUFA	32,54[a]±0.05	44,37[b]±0.06	69,78[c]±0.07
PUFA	29,69[a]±0.11	24,02[b]±0.012	17,50[c]±0.04
n 3-PUFA	12,70[a]±0.08	6,63[b]±0.06	2,80[c]±0.11
n6 -PUFA	16,55[a]±0.12	17,05[a]±0.08	14,61[b]±0.04
n6/n3	1,30[a]±0.06	2,57[b]±0.07	5,21[c]±0.06

Table. 1. Quantitative fatty acids content in hamburger of goldfish, carp and a commercial with Nile Perch (percentage).

- SFA saturated fatty acids
- MUFA monounsaturated fatty acids
- PUFA polyunsaturated fatty acids
- n3 omega 3
- n6 omega 6

Smart labels for Lake Trasimeno fish products

The method chosen to check the quality of the cold chain of Trasimeno fish product is the Time Temperature Indicator (TTI) label.

The usage of TTI for the evaluation of thermal abuse of food products has been verified in the scientific literature (for instance Mai et al. 2011). The system is characterized by a transparent label applied on a white one; the first becomes coloured if exposed over a temperature threshold.

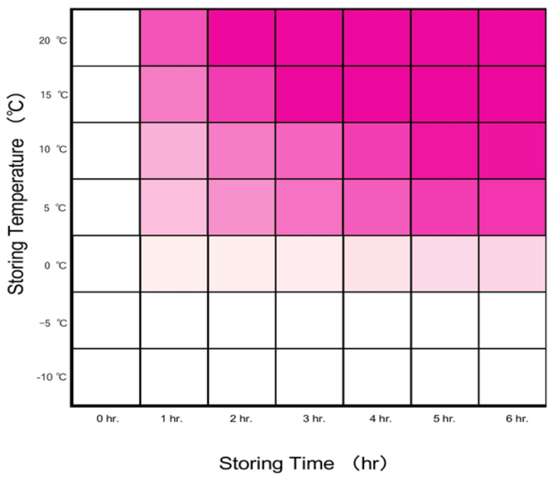

Fig. 1. Example of the relationship between colour intensity, storing temperature and storing time.

The TTI label selected for the project should be applied to the packaging in a temperature range between -5 °C and 0 °C. The transparent label does not became intensely coloured if exposed to temperature up to 20 °C for less than 30 minutes.

These systems can be also employed by the end-user (consumer) to verify if the products marked with the TTI are properly stocked after their purchase.

In fact, they do not request a data logger or a data reader to be consulted; the intensity of the color is directly proportional to the time of exposure to temperatures higher than the threshold value and size of the overrun (Fig. 1).

Result and discussion

The amount of PUFA, MUFA and SFA of goldifish Hamburger were different from the other two products. It is worth noting that goldfish hamburger may provide a considerable amount of PUFA and in particular n-3 fatty acids in comparison with carp Hamburger and the commercial one. n3 PUFA approximately are represented by 1.92 % of EPA (Eicosapentaenoic acid) and 6,33 by DHA (Docosahexaenoic acid). From a nutritional point of view, the EPA + DHA content is of great interest because of the role of these fatty acids in the therapy and prevention of cardiovascular diseases (Uauy & Valenzuela, 1992). The n-6/n-3 ratio of goldfish hamburger give an acknowledged nutritional index for human health, the value in goldfish hamburger was lower than that of the other products and of the value reported by other authors (Dal Bosco, 2010). A decrease in the n-6/n-3 ratio in the human diet is essential to prevent coronary heart disease by reducing plasma lipids and to reduce the risk of cancer (Kinsella, Lokesh, & Stone, 1990). Nutrition advisers recommend an increased intake of n-3 in human diets with a reduction of n-6/n-3 ratio to values below 4 (Kark, Kaufmann, Binka, Goldberger, & Berry, 2003).

These results suggest that goldfish hamburgers are characterized by a high nutritional value and the technological process can be a strategy to enhance the value of this fish. Furthermore the preservation of quality of the product can be assured by the application of TTI technology, a simple, inexpensive device that indicates with an easily measurable, time temperature dependent change the temperature history and quality status of the food they are attached to. The need to assure the quality of food to the final consumer is the main goal of every subject involved in the supply chain, especially when the food has to be stored and processed under particular conditions. This is true for fish, that always needs to be at the right temperature: modern technologies help to manage the Cold Chain, for example TTI can monitor the temperature the food has been exposed to throughout its life.

The employment of an user friendly quality indicator will give value to the innovative fish products developed thanks to the activities of the PSR Umbria Project, making them more attractive for consumers.

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An effective comparison of the production methodologies of nanocrystalline cellulose (NCC) obtained from *Phragmites australis*

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Keywords: Nanocrystalline cellulose, biorefinery, bio-based product, *Phragmites australis*, ionic liquids, acid hydrolysis

Introduction

Nanocrystalline cellulose (NCC) is an high quality bio-based product, obtainable from cellulosic materials and its relevant cross-sector properties have been largely demonstrated (Habibi et al., 2010, Dufresne et al., 2000, Brinchi et al., 2013). The possibility to produce such a precious by-product from residual and marginal matrices could represent an opportunity for rural lands (e.g. lake riversides), offering an innovative way to save resources and to produce energy and bio-chemicals. The energy valence of the ligno-cellulosic residues is the more explored, indeed several species of ligno-cellulosic residues have been already used to produce bioethanol (e.g. Cotana et al., 2014[(a)]). The production of high quality bio-based materials is instead the more innovative research task. Currently, a major barrier to be overcome is the sustainability of the production process, looking forward for industrial scaling up purposes. A promising production method consists in the use of ionic liquid technique (e.g. Zakaria et al., 2011), allowing the deconstruction of cellulose and the reclaiming of its crystalline content, using sustainable components. The present work will present the main results coming from the production of cellulose nanocrystals from *Phragmites australis* that is a very common arboreal variety widespread along lake rivers. In this context, two different methods were applied to obtain NCC: the method including an acid hydrolysis step, and the procedure exploiting the green ionic liquids.

Materials and methods

Materials

The feedstock used in the traditional method was *Phragmites australis (P.a.)* ground with Retch mill, and sieved to 0.5 mm (P.a. S2 sample). In the experimentation with ionic liquids five types of feedstock were tested: *Phragmites australis* chipped, size 1-2 cm (P.a. S1 sample); *Phragmites australis* ground with Retch mill, sieved to 0.5 mm (P.a. S3 sample); *Phragmites australis* after Steam Explosion pretreatment (R_0[8] = 3.6) (P.a. S4 sample); *Phragmites australis* after Steam Explosion pretreatment (R_0 = 4.0) (P.a. S5 sample); *Phragmites australis* after Steam Explosion pretreatment (R_0 = 4.4) (P.a. S6 sample).

[8] R_0 is the severity coefficient of a classic Steam Explosion pretreatment process, as defined for instance in Cotana et al, 2014[(a)].

All ionic liquids were purchased from Sigma Aldrich (Missouri, United States). [EMIM][Ac] (1-Ethyl-3-methylimidazolium acetate) was > 90% pure and [BMIM]HSO_4 (1-Butyl-3-methylimidazolium hydrogen sulfate) was BASF quality.

The traditional methodology of NCC extraction

The extraction methodology consisted of a five step protocol allowing the separation of the nanocrystalline content of cellulose (Cotana et al., 2014[(b)]). The samples obtained from this trial were deposited and dried on special support and analyzed by scanning electron microscopy (SEM).

The ionic liquids (ILs) methodology of NCC extraction

Pretreatment of biomass with [EMIM][AC].

Phragmites australis was dissolved in [Emim][Ac] and a strongly basic aqueous solution of phosphate was added. The resulting three-phase system has a salt-rich aqueous phase, a solid-phase rich in cellulose, and an IL-rich phase containing most of the lignin. For every sample, 2 g of biomass were added to 20g [Emim][Ac] and incubated at a temperature of 140°C for 1h with stirring. The samples were then cooled to 70°C, and 20.0g of 40.0 wt% K_3PO_4 solution were added to precipitate the cellulosic components [Shill et al. 2010]. The samples were cooled to room temperature and centrifuged to provide a well-defined three-phase system. The IL and salt-rich phases were removed, and the remaining solids were washed with a water:acetone solution (1:1, v/v) and then with citrate buffer (50mM pH 4.8), to remove any residual IL or phosphates.

Preparation of Cellulose Nanocrystals with [BMIM]HSO_4.

Two samples, one obtained from the ionic liquid treatment and one by the traditional process, were treated with the ionic liquid [BMIM] [HSO_4] in a 100ml flask. The ratio of solute/solvent was 1:30 w/w. The process was carried out at a temperature of 90°C using diathermic oil bath for 1h under vigorous stirring [Man et al. 2011]. To stop the reaction an equal volume of cold deionized water was added and the solution was sonicated for 30 minutes in the ultrasonic bath. The solid components obtained were washed several times with deionized water and subsequently centrifuged at 3000 rpm for 15 minutes. All the supernatant obtained were collected and centrifuged again at 7500 rpm for 30 minutes in order to sediment the nanocrystalline component. The pellet obtained was re-suspended in deionized water and left on dialysis overnight. As the same with the traditional methodology (par. 2.2), the samples obtained from this trial were deposited and dried on special support and analyzed by scanning electron microscopy (SEM).

Results

The preliminary results of the experimental campaign are summarized in Table 1. In particular, for each initial sample typology, a specific SEM analysis was carried out, in order to verify the presence of NCC after the different production methodologies.

	Type of pretreatment carried out		**Type of NCC production methodology**			
Typology of initial sample	**Traditional method** (Cotana et al, 2014[(b)])	**Ionic liquid [EMIM][Ac]** (Shill et al. 2010)	**Ionic liquid [BMIM]HSO_4** (Man et al. 2011)	**Acid Hydrolysis** (Cotana et al, 2014[(b)])	**Name of obtained samples**	**Presence of NCC (Y/N)**
P.a. (S1)		X		X	P1	N
P.a. (S2)	X (Step1+Step2+Step3)		X (*)		P2a	N
				X (*)	P2b	Y
P.a. (S3)		X	X (*)		P3a	N
				X (*)	P3b	N
P.a. (S4)		X		X	P4	N
P.a. (S5)		X		X	P5	N
P.a. (S6)		X		X	P6	N

(*) a half of the initial measured weight

Table 1. Relevant processes of the experimental campaign

Indeed, the S1-S4-S5-S6 samples were firstly pretreated with the [EMIM][Ac] ionic liquid and in a second phase, they were destined to the acid hydrolysis. This particular subsequence of treatments was chosen since after the [EMIM][Ac] pretreatment, the samples appeared not enough deconstructed. Therefore, the more aggressive acid hydrolysis process was applied but not significant presence of NCC was detected for P1, P4, P5, and P6, as shown in Fig. 1. In addition, concerning S2 and S3 samples, the pre-treated biomass was equally divided in two parts, allowing to test the two different NCC production methodologies (i.e. acid hydrolysis and [BMIM]HSO_4). In this case, not relevant presence of NCC was detected for P2a, P3a and P3b produced samples, while, well-defined NCC particles were obtained for the P2b sample, as shown in Fig.1

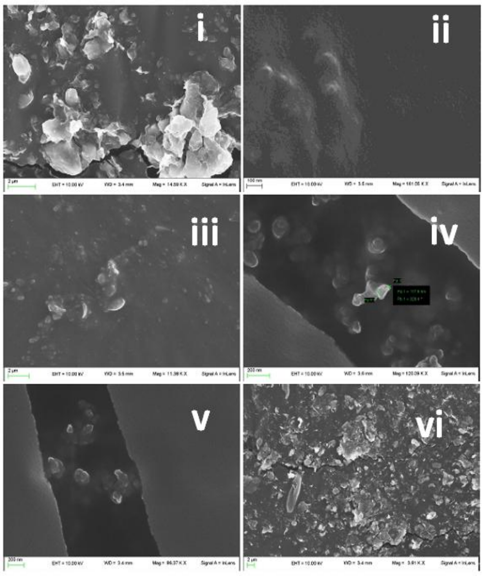

Fig. 1. SEM images (P1-P6) of the treated samples of *Phragmites australis*

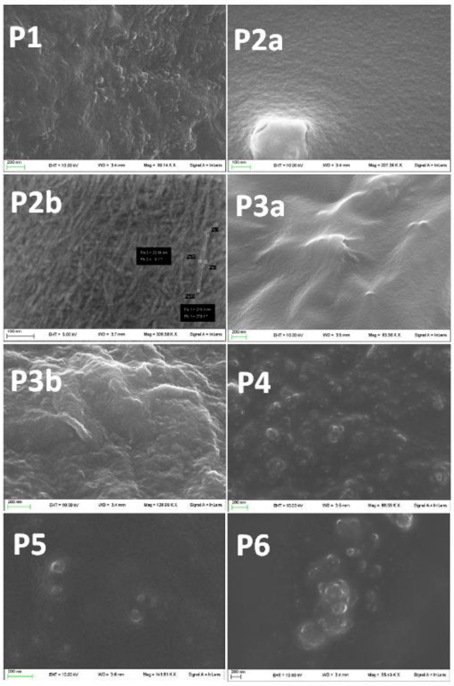

Fig.2. Some examples of the monomeric sugars thin film (ii, iii, iv, v) and the un-decostructed lignocellulosic biomass (i, vi)

Discussion

The experimental campaign mainly confirmed the effectiveness of the acid hydrolysis methodology used for the production of NCC particles from ligno-cellulosic biomass (Bandeson et al. 2006) as confirmed by the SEM images of P2b sample in Fig 1. On the other hand, the ionic liquid methodology, even if promising in terms of production efficiency of NCC from MCC (Man et al. 2001; Zakaria et al. 2011), it did not produced significant results in this experimental campaign. Anywhere, the not successful production of NCC particles can be justified by the structure of the initial biomass and in particular by the inaccessibility of crystalline cellulose and the not sufficient pretreatment applied.

In addition, some NCC particles could be probably covered by the presence of a thin film of monomeric sugars. They were mainly produced during the hydrolysis of amorphous cellulose, as shown in Fig.2. This picture reports some examples of the over-mentioned effects and that the ionic liquid is not working in an optimized way for ligno-cellulosic biomass.

Acknowledgements

The authors would like to acknowledge the CIRIAF/CRB Section laboratories for providing the equipments for the experimentation. In addition, particular gratitude goes to the Department of Physics of the University of Perugia for performing the SEM analises.

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Simultaneous saccharification and fermentation of common reed (*Phragmites australis*) at high solid loading

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Keywords: Ethanol, common reed, Simultaneous saccharification and fermentation, High solid loading

Introduction

Lake environments offer a good availability of biomass such as common reed (*Phragmites australis*), a perennial grass that grows in wetlands or near inland waterways. Traditionally, common reed is used for local handicrafts such as roofs, baskets and beach umbrellas, Sathitsuksanoh et al. (2009). Thanks to recent advancements in conversion technologies, common reed's processing residue can be used as a feedstock for the production of cellulosic ethanol, giving an added value to rural economy.

In the present study an optimization of the bioethanol production process using steam explosion pre-treatment at different severity parameter (R_0) values was carried out. The ethanol yield was also investigated using different values of solid loading at the same enzyme dosage and R_0, with a simultaneous saccharification and fermentation (SSF) process.

Materials and methods

Feedstock

Arundo phragmites L. was gathered from lake Trasimeno. The moisture content was equal to 5.95%. The common reed was chipped to a final size of 1-2 cm and then stored in the dark.

Steam explosion, analysis of raw material and water insoluble substrate

The steam explosion pre-treatment was described elsewhere Cotana et al. (2014).

The composition of solid materials (RM and WIS) was determined according to the National Renewable Energy Laboratory (NREL, Golden, CO) analytical methods for biomass.

SSF

SSF was carried out in a 5-L automated reactor (Biostat® A-Plus – Sartorius) for 96 h and filled to a final weight of 2000 g (WIS + water).

In the first step of SSF the WIS was pre-hydrolyzed at 50°C and pH 5 for 24 h using Cellic™Ctec2 enzyme provided by Novozymes. In the seconds step, the system was cooled down to 37°C and Ethanol red® dry yeast was inoculated directly into the reactor. The second step was carried out for 72 h.

An enzyme dosage level of 20% w/w (g enzyme/g cellulose) and a suggested dosage (1.41 g) of dry yeast were employed for all trials.

Glucose and ethanol concentrations from SSF were determined by HPLC (Ultimate 3000 – Thermo Scientific).

Results

The raw material composition was found to be:

- 38.13% cellulose
- 20.51% hemicellulose
- 3.92% acetyl
- 6.90% extractives
- 4.25% ashes
- 23.02% lignin
- 3.28% others.

Three $LogR_0$ values (3.6, 4.0 and 4.4) were used to pre-treat *Arundo Phragmites L.* The cellulose content in the pre-treated WIS increased between $LogR_0$ 3.6 (48.96%) and 4.0 (54.45%) and slightly decreased for $LogR_0$ 4.4 (52.03%). The trend was different for the lignin fraction which increased with the severity of the pre-treatment (28,87% - 33,99% - 38,63%). Hemicellulose is easily hydrolyzed by the pre-treatment hence its quantity decreased for high severity factors, Cotana et al. (2014).

According to literature, increasing the severity factor made cellulose more accessible by the enzyme, Ramos et al. (1992). This is clear from the converted cellulose after 24 h (C_{24} in table 1). However high values of $LogR_0$ also determine a cellulose mass loss, so it is important to find the right compromise between a good deconstruction of the biomass and a reasonable loss in cellulose. Besides, the structural carbohydrates lost in the process are hydrolyzed into the liquid fraction to simple sugars which, for vigorous pre-treatment, can be further transformed into SSF inhibitors such as 5-hydroxy methyl furfural and furfural, Söderström et al.(2003).

WIS	**Log R_0**	**DM(%)**	**C_R(%)**	**G_{24}(g/L)**	**E_{96}(g/L)**	**C_{24}(%)**	**C_{96}(%)**	**OY_r(%)**
AP3,6	3,6	15	100,00%	39,25	19,70	43,70	43,00	43,00
AP4,0*	4	15	97,71%	53,68	34,21	49,29	61,59	60,18
AP4,4	4,4	15	92,25%	66,97	41,49	62,43	75,83	**69,95**
AP10	4	10	97,71%	42,73	26,71	60,44	74,08	**72,38**
AP15*	4	15	97,71%	53,68	34,21	49,29	61,59	60,18
AP20	4	20	97,71%	67,41	42,44	42,38	52,31	51,11

Table 1. Cellulose balance for SE pre-treatment; concentrations of glucose and ethanol; cellulose converted and overall relative yield. *AP4.0 and AP15 are the same sample

DM contribute

According to the considerations above, a $LogR_0$ value of 4.0 was chosen and fixed while different dry matter loadings were investigated in terms of ethanol production. This $LogR_0$ value allowed a good cellulose accessibility and modest mass loss (Table 1).

High solid loadings are convenient because a larger quantity of substrate is processed at the same time. On the other hand the system is subjected to a higher stress due to reduced mass transport, Spindler et al. (1988) and high content of lignin which inhibits the SSF process, Nakagame et al. (2010).

The dry matter values investigated were 10%, 15% and 20%. The inferior DM point was selected because below this value ethanol production would be lower than 4% v/v. This is considered a threshold beneath which distillation is considered energetically-economically inconvenient, Vane (2008). The trials' results are shown in table 1.

$LogR_0$ contribute

In order to investigated the $LogR_0$ effect on cellulose conversion at high solid loadings, a DM of 15% was chosen. At this value the final ethanol production found in the above mentioned experiments was 4.3% and the overall relative yield (OY_r) was 60.18%. A DM of 10% shown an high OY_r (72.38%) but the final ethanol concentration was 3.3% v/v. Conversely, a DM of 20% shown an opposite trend, respectively 51.11% OY_r and 5.3% v/v final ethanol concentration. Despite 5.3% v/v was the highest value, an OY_r of 51.11% is to consider low in an industrial scenario, Hamelinck et al. (2005). The results are shown in table 1.

Discussion

Figure 1 shows the ethanol concentrations increase during the trials for three samples AP3.6, AP4.0 and AP4.4.

Increasing the $LogR_0$ the amount of ethanol produced at the end of the SSF was larger, as expected (table 1).

Figure 2 displays the trend of all samples in terms of: C_r, C_{24}, C_{96} and OY_r.

The values of C_{24}, C_{96} and OY_r increased for increasing $LogR_0$ values and decreased for increasing DM values, as expected.

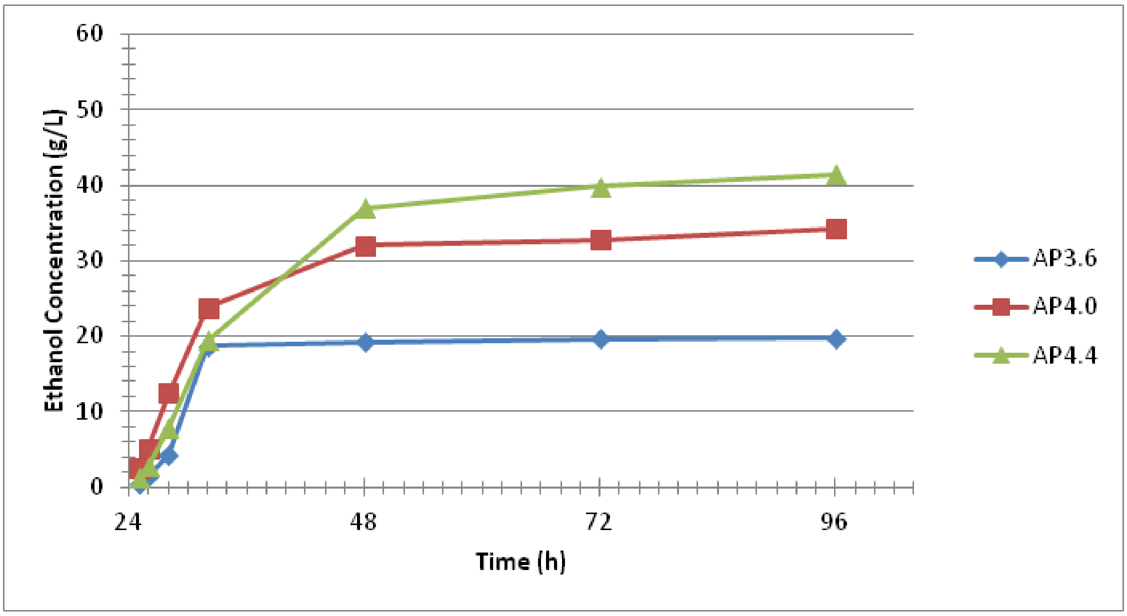

Fig. 1. Ethanol production (g/L) during the trials

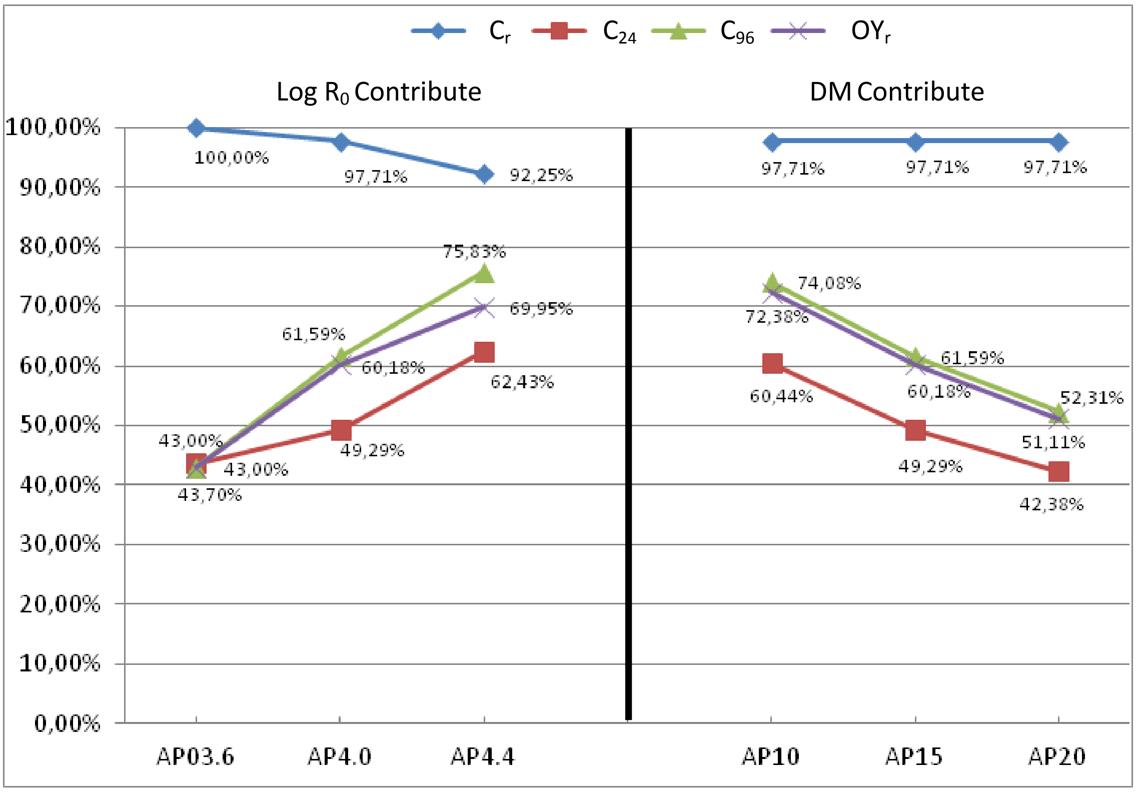

Fig. 2. SSF results for all the trials performed in terms of C_r, C_{24}, C_{96} and OY_r

The highest OY_r was obtained for sample AP4.4 (69.95%) and AP10 (72.38%) corresponding to 15.80 and 16.35 g ethanol/100 g $RM_{dry\ basis}$, respectively. Despite the sample AP10 reached the highest OY_r, the final ethanol concentration (3.4% v/v) was below the 4% threshold limit. On the other hand AP4.4 showed an OY_r slightly lower but a good final ethanol concentration (5.3% v/v).

An interesting result was that the values of C_{96} and OY_r for AP4.4 were similar to those of AP10, this was probably due to enhanced cellulose accessibility which balanced cellulose mass lost.

In conclusion, the experimentation proved the suitability of *Arundo Phragmites L.* as a feedstock for the production of lignocellulosic ethanol, showing conversion yields similar to those found in literature, Öhgren et al. (2007), for both high and low solid loadings. Therefore it would be interesting to carry out further experiments using a 20% DM and pre-treating the biomass above $LogR_0$ 4.4.

ABBREVIATIONS AND SYMBOLS LIST
SE = Steam Explosion
R_0 = Severity factor
SSF = Simultaneous saccharification and fermentation
WIS = Water insoluble substrate
DM = Dry matter
RM = Raw material
G_{24} = Glucose concentration after 24 h of SSF
E_{96} = Ethanol concentration after 96 h of SSF
C_r = Cellulose recovered after steam explosion pre-treatment
C_{24} = Cellulose converted into glucose after 24 h of SSF in respect to the theoretical yield
C_{96} = Cellulose converted into ethanol after 96 h of SSF in respect to the theoretical yield
OY_r = Overall relative yield expressed as g produced ethanol/100 g $RM_{dry\ basis}$ * theoretical yield

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A new model for photovoltaics integration with hydropower: a case study

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Keywords: hydropower, photovoltaics, lake, turbine

Introduction

In the summertime, when water is mostly needed and lacking, artificial reservoirs for hydropower production are recharged during the night to be able to provide water for the day after by using the huge availability of unused nocturnal energy (Biscarini et al., 2013). The reservoir acts as storage element and water source for energy production. This work presents a small scaled model for hydropower that can be applied to little lakes as water sources to replace lacks in photovoltaic production (PV). Imbalances in the electricity grid caused by non-programmable renewable energy sources' variability as wind and solar ones (IEC Commission, 2012), can be minimized by integrating the energy production plants with users needs, via storage systems. A water based storage system, differently from a lithium battery, consists of a gravity water tank, connected to a little lake or water basin to produce hydropower with a pumping system.

The presented system combining photovoltaic systems with hydropower, aims at creating a system for continuous energy production avoiding the sudden energy lacks typical in solar plants applications.

Materials and methods

Umbria region, because of its high wood surface and water, is an area with a high vocation for the construction and maintenance of little lakes at the service of small rural building complexes (Agostini et al., 1999). The water that feeds the lakes comes mainly from aquifers emerging from the ground surface and the maintenance of water levels is ensured by the presence of artificial bank made of clay soils.

The research shown in the present work is framed within the project TIAR, Italian acronym for Rural Hydraulic Architectural Tower for Energy (Cotana et al., 2012. Cotana et al., 2013). The activities mentioned above have allowed to create a digital model of a small compound of rural buildings where energy enhancement refurbishment has been designed and simulated. The rural tower became, from a chimney tower for drying tobacco, an energy tower for energy production: an energy-efficient system, with low environmental footprint (Lovins Armory, 2011), based on the integration of renewable sources. The building pertinence and its front view are shown in Figure 1-a, b.

The neighboring lake is characterized by a 800 square meters of water surface; the deepest point of the lake is at 2.5 m under the free surface; the volume that can be stored inside the tower tank is about 36 cubic meters. The tower has a horizontal section of 4x3 m, and the tower tank height corresponds to 3 m).

Fig. 1 a, b. The building compound, the lake and its front view

First of all, it can be noticed that the time course of the power associated to the photovoltaic panel has a bell curve distribution during the course of the year. The amount of produced energy, represented by the area under the graph, depends on the physical and geometrical parameters such as the latitude, the inclination of the panel, the orientation with respect to the cardinal points, the absence of direct and indirect shadows. Being able to combine the energy supply and the energy demand implies the knowledge, for the whole year, of the electricity production from renewable energy plants and the electrical needs of the building. In addition, another phenomenon of interference in power generation is represented by frequent lacks in solar radiation, caused by weather phenomena such as cloud, fog or rain. In these cases, the required energy could be produced by the released water flowing through the hydroelectric turbine.

The combined sources for the electricity production are represented by the photovoltaic systems above the roofs facing South-East, and the hydroelectric turbine placed in the lake, named PAT (Pump As Turbine). The turbine collects water from a hanged tank positioned inside the tower and it refills the tank by taking water from the lake.

The experimental applied methodology consisted of the following steps:

1. analysis of the solar radiation by means of a weather station to evaluate throughout the year the total energy to be converted by the PV panels;
2. annual monitoring of the lake level and estimation of storage volumes;
3. estimation of the electric power consumption for a countryside multifamily house by simulating different households' thermal zones, realistic occupancy and building physical and architectural features.

Results

The monitoring carried out in 2013 showed that the height between the turbine position and the lowest point of the tower tank is kept around 45 meters. Therefore, this will be a key design parameter for the implementation of the electric turbine. The ability to adjust the flow rates (5-10 l/s) is also guaranteed consistently with the emptying of the tank inside the tower and to cover the lacks produced by the mentioned weather variability.

It seems clear that the battery cover may be helpful in cloudy conditions. The maximum hydropower is 4.4 kW.

Figure 2 shows the production of the PV panels together with the electric energy consumption simulated by considering room electricity, lighting, cooling and domestic hot water production in Energy Plus environment. The modelled architecture consists of a simple flat roof multifamily house with 3 residential units, 120 m^2 each of floor surface. The exposed roofing surface area available allows to setup more than 120 square meters of photovoltaic panels, with an equivalent power of 18 kW peak. As observed in Figure 2, in some winter months the production of photovoltaic electricity is not sufficient to cover the electric consumption. Therefore, in such cases, the production can be supplied by the exclusive use of lithium-ion battery, with a capacity at least 2,000 kWh (Hill et al., 2012). In the other months it is always possible to cover those needs with the help pf the storage water system, especially in the summer with high energy consumption for cooling.

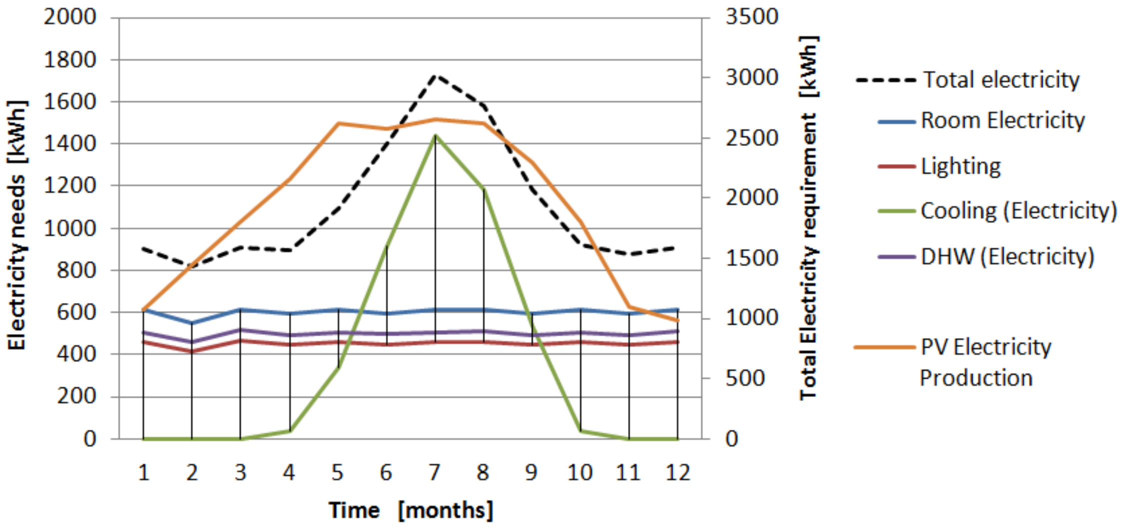

Fig. 2. Energy needs and production by PV

Discussion

The calculation areas subtended by the curves of photovoltaic energy (21,600 kWh/year) compared to the estimated production from hydropower (3,000 kWh/year) showed that, with adequate margin of safety, all the electrical consumption of the building could be covered during the whole year. A management software, based on historic and prediction data process about both energy production and consumption, is required to decide which storage system comes into operation in a certain time. The choice of the maximum capacity of lithium battery was designed according to the exceeding energy by PV power and on the required energy to recharge the tank with the PAT turbine in full battery condition.

The hydroelectric turbine investment costs and management were greatly reduced. Adding up the costs for the construction of the tower tank and PV plant integrated with battery, all the energy cost savings (7,000 €/year for the residential complex) allowed to payback the entire investment in 6 years. Furthermore, the sized system avoided the production of carbon dioxide by 11 tons/year .

The system demonstrated to have interesting potentialities if applied to the large number of rural abandoned sites that can be refurbished by means of hydroelectric potential, determined by considering the position of the lake with respect to buildings. Such system could be also suitable for applications in non-grid-connected compounds

Acknowledgements

The authors would like to thank the Ministry of Agriculture for supporting the project and the owner of the building for the measurement for availability to perform measurements and calculations.

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Energy enhancement of *Arundo phragmites* reed as biofuel for thermal boiler

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Keywords: Biomass boiler, reed, thermal energy valorization, lake biomass

Introduction

Biomasses represent nowadays one of the most performing renewable energy sources. A biomass is any organic residual from biological activities derived directly or indirectly from the photosynthesis process. The first definition of biomass has been dictated by the regulation n°387 (29/12/2003) followed by the regulations n°28 (3/3/2011). Between 2000 and 2011 the number of biomass plants in Italy has increased with an average rate of 19%. In particular, in the last three years the installation of more than 260 new bio-energy plants has been detected. Most of these innovative bio-energy plants are fed with biogas (65%), bio-liquids (22%), and biomasses (13%).

In this scenario, a peculiar biomass is represented by the common reed, a very hardy native species which grows spontaneously along the banks of streams or ponds of water. This reed can reach 6-7 m, and its use for energy purposes can be carried out through different strategies:

- extraction of nano-crystalline cellulose to be used as additive for improving the mechanical/ optical properties of other materials;
- production of a biofuel through enzymatic hydrolysis;
- production of solid biofuel in the form of briquettes.

In this paper, the use of a spontaneous reed typical of the area of the Trasimeno lake i.e. *Arundo phragmites* as biomass in the form of briquettes is addressed (Fig. 1).

Fig. 1. Picture of the *Arundo phragmites*, typical of the Trasimeno lake's area, and of the briquettes made from the reed

The *Arundo phragmites* is a native species of the Trasimeno area which grows along the shores of the lake up to a height of 2-3m. The need for maintenance of the lake's shores offers the possibility of collecting this biomass in large quantities. Therefore, this work deals with the possibility of harvesting and processing the residual reed for the production of biofuel with a low moisture content to be stored and transported in the form of briquettes to supply biomass boiler for thermal-energy production. In particular, a school building situated in the Trasimeno lake area is selected as case study. An energy, economic and environmental analysis is provided, with reference to the biomass collection, transportation and post-processing for thermal-energy production in the view of the replacement of the current building's fossil fuel boiler with a biomass plant.

Materials and methods

The methodology consisted of the following steps:

- laboratory characterization of the *Arundo phragmites*;
- energy analysis of the reed as biofuel;
- economic and environmental analysis.

Laboratory characterization

The in-lab characterization required the collection and sampling of the *Arundo phragmites*. Therefore, the components of the reed were determined through hydrolysis and HPLC- High Performance Liquid Chromatography according to the National Renewable Energy Laboratory (NREL) methods for biomass (Cotana et al., 2013):

- 38.13% cellulose
- 20.5% hemicellulose
- 3.92% acetyl
- 6.90% extractives
- 4.25% ashes
- 23.02% lignin
- 3.28% others.

Case study

The case study building is a 1970's school situated in Castiglione del Lago, a village close to the Trasimeno lake. The current heating energy plant consists of a traditional methane boiler (650W) with hot water radiators. In this scenario, an integrated architectural and energy retrofit is proposed for improving the building thermal-energy performance. It consists of: (i) the substitution of the methane boiler with a low-impact biomass plant, using the residual reed, and (ii) the replacement of the existing windows with more performing low-emissivity double-glass windows. In fact, the area where the school is located is rich of *Arundo phragmites*, which is already used as insulating building material given its high thermal/ acoustic potential.

According to the Trasimeno Lake's Regional Plan, a quantity of 20tons/year of residual reed can be collected for the biofuel's production. This amount of residuals used as biofuel powering a more effective energy plant could provide several benefits:

- Reduction of the methane consumption's costs;
- Reduction of the greenhouse gases emissions;

- Creation of a pathway for the harvesting and energy enhancement of residual biomass otherwise dispersed;
- Generation of a local micro-economy related to the collection, transportation, processing and re-use of the reed with the consequent maintenance of the lake's shores.

Therefore, after the collection of the reed, the residuals could be transported and processed in order to produce biofuel in the form of briquettes.

Results

An energy, economic and environmental analysis of the benefits generated by the installation of a biomass plant using the Trasimeno lake's reed in the case study building is performed. In particular, the thermal power demand of the building to be provided by the new biomass plant is estimated to be of about 300kW. Therefore, the existing methane plant results to be oversized. By considering the type of building and the operating schedule of the energy plants (800h/year), an energy request of 240,000kWh/year is determined. Therefore, after the test of residual reed's energy efficiency through dedicated sampling and the evaluation of the moisture content through muffle furnace, the briquettes are realized with a 45% density increase. The final heating power provides about 16-17MJ/Kg, with an humidity content of about 10-15%, respectively.

In order to fulfill the building energy demand for heating, 60tons/year of briquettes are requested, and the available residuals are able to meet only 1/3 of the building's energy demand. Therefore, 20tons/year will be provided by the residual reed, and the remaining briquettes needed (40tons/year) will be purchased.

The economic analysis showed that, with equal thermal energy to produce, the use of the methane boiler with a thermal efficiency of 88% would lead to a methane consumption of 27,300m^3/year. Therefore, the installation of the biomass plant could lead to a saving of 22,000€/year, corresponding to the cost of the avoided methane. The operative costs should include the transportation of the residual biomass (4€/tons) and of the remaining briquettes needed (5€/tons), in addition to the cost of the purchased briquettes (0,20€/kg), and the staff (5,000€/year).

Table 1 summarizes the economic analysis in terms of investment costs and operative costs of the intervention.

Description	Investment Costs	Description	Operative Costs
Machine for briquettes [€]	4,000	Biomass transportation (20t) [€/year]	80
		Briquettes transportation (40t) [€/year]	200
		Ash removal [€/year]	---
Biomass boiler [€]	45,000	Briquettes purchase [€/anno]	8,000
		Electric consumption for briquettes [€/year]	1,500
Machine's components [€]	3,000	Staff	5,000
TOTAL [€]	52,000	**TOTAL** [€/anno]	14,780

Table 1. Economic analysis of the intervention

The payback time of the intervention is estimated to be around the 7th year (Fig. 2).

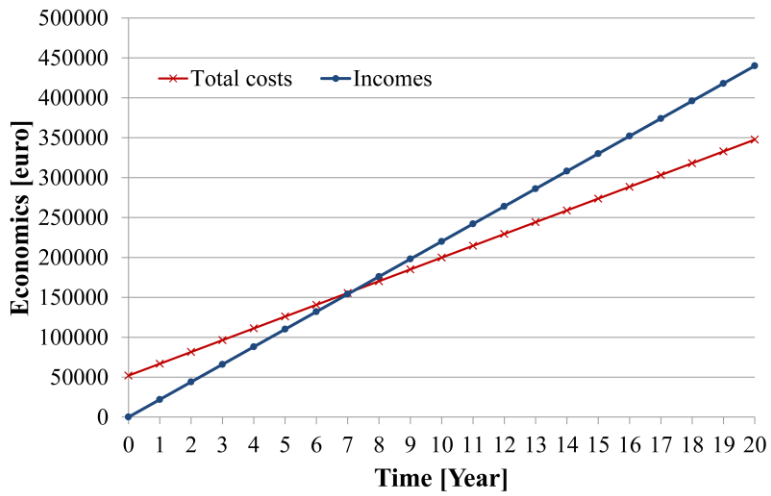

Fig. 2. Payback time

The environmental analysis shows that for every m^3 of burnt methane, 2kg of CO_2 are produced. Therefore, the total amount of CO_2 avoided by replacing methane with reed as biofuel is 55tons/year.

Discussion

In this paper, the energy potential of the Arundo Phragmites as biofuel was evaluated. To this aim, a school building in the same lake's area was selected as case study. An energy/ environmental/economic analysis of the replacement of the existing plant with a biomass plant powered by the residual reed was performed. Therefore, the collection of the reed could serve both environmental and economic benefits in terms of (i) preservation of the natural environment of the lake area, (ii) offset of CO_2 emitted and (iii) energy saving from the use of local and clean energy source.

The results of the energy analysis showed that the heating power of the residual reed corresponds to about 17MJ/Kg. Therefore, in order to fulfill the building energy demand, 60 tons/year of briquettes are needed, where 20tons/years are provided by the residual reed and the remaining 40tons/year are purchased.

The economic analysis demonstrated that a payback time of 7 years is needed to recover the initial investment. The environmental analysis showed that the replacement of the methane plant will produce a CO^2 offset of 64tons/year.

Acknowledgements

The authors would like to thank the director and the teachers of the school of Castiglione del Lago for allowing the surveys in order to perform the analysis of the energy plants.

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The effect of lake microclimate on thermal-energy behavior of buildings

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Keywords: Lake environment, microclimate monitoring, thermal-energy performance of buildings, heating degree-hours method

Introduction

In this preliminary study, the winter microclimatic monitoring of the Lake Trasimeno's environment was carried out. In this scenario, the effect of the lake's presence in thermal-energy performance of buildings, in comparison with urban and suburban areas, was evaluated.

Materials and methods

The Lake Trasimeno, is the largest lake of the middle Italy with a basin's area of 128km^2. The average depth is 4,3 m and the maximum depth reaches up to 6m. It is situated about 23Km west of Perugia (350 m a.s.l.), the main city of Umbria Region, and about 17 km west with respect to Colle della Trinità, a hill situated in a suburban area (700m a.s.l.) between the lake and Perugia. The lake is also located at 258m a.s.l. and about 100 km far from the nearest area of the Adriatic Sea (on the east side) and the Tyrrhenian Sea (on the west side), respectively.

An in-field monitoring campaign was carried out during winter 2014, from January to April. Microclimate monitoring sensors, able to measure the two main environmental parameters, i.e. dry bulb air temperature and relative humidity, were positioned in four locations (points "1", "2", "3" and "4" in Fig. 1) close to the lake, according to the cardinal points. These data loggers can record temperature between -25 °C and +85 °C and relative humidity between 0% and 100%. Additionally, the meteorological data of two weather stations, situated on the east side of the lake in a suburban ("Sub" in Fig. 1, Colle della Trinità) and urban ("Urb" in Fig. 1, Perugia) area, were used in this study for a comparison analysis. In particular, air temperature, relative humidity, global solar radiation, wind speed and direction were measured and collected every 10 minutes by dedicated data-logger apparatus. Then, hourly data were analyzed for the scope of this work.

The map of Lake Trasimeno's basin, with the spatial distribution of sensors and stations, is shown in Fig. 1.

Fig. 1. Map of the Lake Trasimeno's basin. Spatial distribution of the microclimate sensors ("1", "2", "3" and "4") and the meteorological stations ("Sub" and "Urb")

Results

In the present work, the air temperature and relative humidity were analyzed in order to describe the Lake Trasimeno's local microclimate.

The climate of the Lake Trasimeno's area is Mediterranean, with a mild winter and dry hot summer. During the monitored period, the average monthly air temperature varies between 6,4 °C in January and 14,6 °C in April.

The environmental parameters of the Lake Trasimeno, used in the following analyses, were calculated as the average of the recorded values from the four stations positioned around the lake. The profiles of air temperature and global solar radiation in the average monthly day of January and April for the monitored areas ("Lake", "Sub" and "Urb") are shown in Fig. 2.

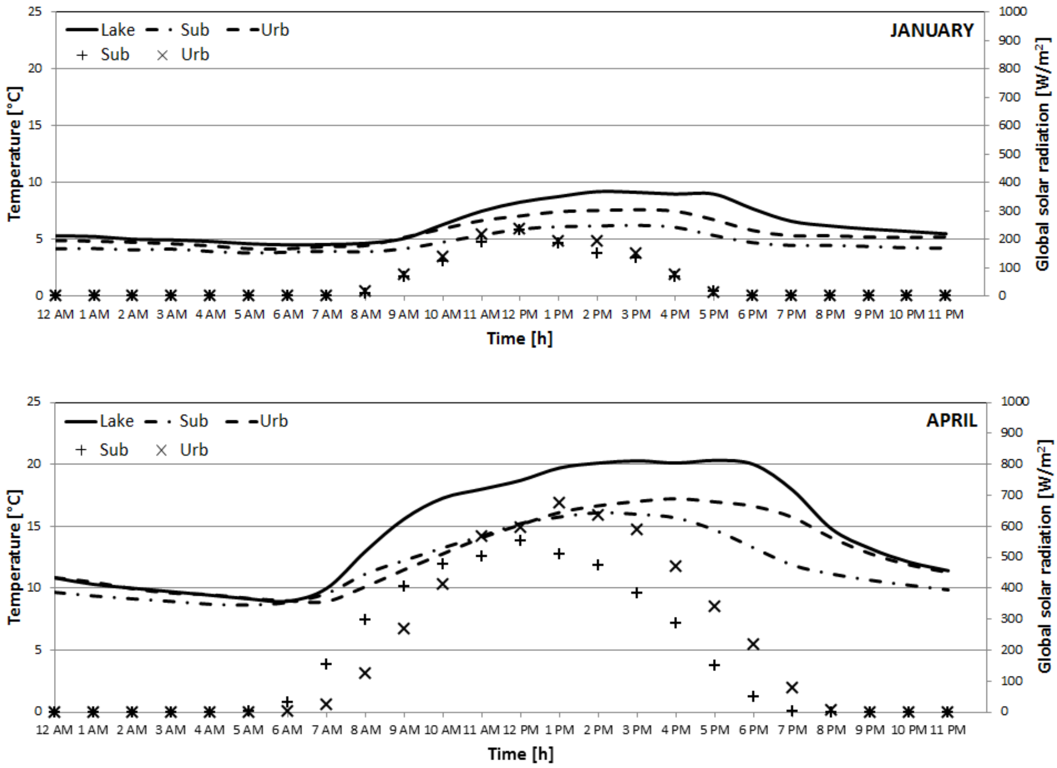

Fig. 2. Profiles of air temperature and global solar radiation related to the Lake Trasimeno ("Lake"), suburban ("Sub") and urban ("Urb") area in the average monthly day for January and April

The mean daily (7 AM – 9 PM) and nightly (10 PM – 6 AM) air temperatures and their standard deviations related to all monitored period were calculated (Giannopoulou et al., 2011). Furthermore, the average monthly air temperatures for January, February, March and April were investigated and the results are listed in Table 1.

	All monitored period (January – April 2014)					
	Average daily air temperature [°C] (7:00 – 21:00)			**Average nightly air temperature [°C] (22:00 – 06:00)**		
	Max	**Ave**	**Min**	**Max**	**Ave**	**Min**
Lake	17,8 ± 5,4	13,2 ± 4,1	6,8 ± 3,4	10,2 ± 2,6	7,9 ± 2,8	6,1 ± 3,0
Sub	13,1 ± 4,6	10,1 ± 3,8	6,5 ± 2,9	8,5 ± 2,9	7,1 ± 2,7	5,9 ± 2,7
Urb	14,1 ± 4,4	11,2 ± 3,6	6,6 ± 3,0	9,9 ± 3,0	7,8 ± 2,9	6,1 ± 3,0

	Average monthly air temperature [°C]			
	January	**February**	**March**	**April**
Lake	6.4 ± 1,5	9.7 ± 2.7	11.1 ± 4.2	14.6 ± 4.1
Sub	4.7 ± 0.8	7.7 ± 1.6	8.9 ± 2.5	11.8 ± 2.7
Urb	5.6 ± 1.2	8.7 ± 1.9	9.8 ± 2.9	12.8 ± 3.0

Table 1. Main statistical analysis data. Air temperature and standard deviation values for the three areas

Looking at the Fig. 2 and Table 1 the results show how, in the monitored winter months, the Lake Trasimeno's air temperature is higher than the urban and suburban temperature. In particular, the air temperature differences, between the Lake Trasimeno's environment and, both, the urban and suburban areas, are higher with higher global solar radiation values. In addition, the mean daily profiles of air temperature in the suburban area are lower if compared with the urban area profiles because of the different altitude of the meteorological stations, but also because usually, the air temperature in the urban area is significantly higher than the corresponding suburban air temperature (Urban Heat Island effect). Moreover, the differences of air temperature between the lake's area and the other two monitored zones are more evident during the daily time than the nightly time.

The mean relative and absolute humidity values are higher in the Lake Trasimeno's area than the urban area. The absolute humidity started from January with 5,5±0,2g/kg to April with 7,6±0,4g/kg in proximity of the lake, while in the urban environment the values are 5,1±0,1g/kg in January and 6,4±0,2g/kg in April. This shows that the differences of absolute humidity between the lake and urban area are higher in the hot months than in the cold months.

Wind speed and direction values recorded in the urban ad suburban areas were therefore investigated to preliminarily assess how the lake's presence affects the two close environments. The wind flow registered by the urban station mainly comes from the North with an average speed of 1,7m/s. The major reason is the presence of the Colle della Trinità hill, which deflects the wind along the north-south axis. When the wind comes from the lake, from north-west and west directions, the average air temperature value recorded in the urban area is 10,8 °C, higher than the air temperature found when the wind comes from all other directions which is 9,7 °C. In the urban area, similar results were obtained about the absolute humidity. In fact, when the wind comes from the lake, the average absolute humidity value is equal to 5,7±1,3g/kg, while when the wind comes from all other direction we observed a lower value of 5,6±1,3g/kg.

Conversely, the main direction of the wind recorded by the suburban station is coming from the South and the average speed is around 0,8m/s. In this case, the lake's effect on the air temperature related to the suburban area is not relevant due to the high altitude of the monitored site. In fact, the average air temperature values when the wind comes from the lake and when it comes from all other directions are similar and close to 9,0 °C.

In this study, the degree-hour method (Papakostas et al., 2005) is chosen for the comparative prediction of buildings' energy demand for heating in the lake, suburban and urban environment. The followed equation was used for the calculation of the heating degree-hour index (HDH) from January to April:

$$HDH = \sum_i HDH_i = \sum_i \left(\max\left(T_r - T_i, 0\right)\right)$$

The different HDH values are obtained from hourly mean temperatures (T_i) of the three areas and the reference temperature (T_r), meaning the external temperature below which the heating system is turned on. It corresponds to 15°C (Giannopoulou et al., 2009).

The HDH indexes found for the lake, urban and suburban zone are 11.486°C, 13.283°C and 15.223°C, respectively.

The results suggest that, being widely different the external air temperatures in the monitored zones, there are different heating energy requirements. In particular, buildings situated in the lake environment need less heating than the other because of the lake's mitigating contribution.

Discussion

The purpose of the work was to investigate how microclimate boundary conditions are influenced by the presence of lakes. The local condition around the lake are significantly different from the local condition that we have in a close urban and suburban zone. This study shows that Lake Trasimeno's presence strongly affects buildings' energy demand in winter. Therefore, this study highlights how the microclimate in close proximity to water resources, e.g. lakes, should be taken into account in order to operate reliable energy predictions of buildings located in those interested areas.

Acknowledgements

The authors thank G. Legumi, G. Castaldo, M. Brozzetti and G. Volpi for allowing the local monitoring of the analyzed areas around the Lake Trasimeno.

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With the contribution of

Chamber of Commerce - Perugia

Umbria Region

Board of Engineers Foundation

Honors Center of Italian Universities

Italian Association of Oceanography and Limnology

Lakes, both natural and artificial are vital and strategic resources for life on our planet. At the same time, they are also highly vulnerable to human activities, especially if they are not properly preserved and used in a sustainable manner. These natural resources and their ecosystems have defined borders, while at the same time also strongly influenced by where they are located. Although there is a geographic limit between a lake ecosystem and neighboring ecosystems, lakes are heavily influenced by the substances entering them in their incoming waters. Moreover, lakes are very complex systems influenced by many different factors, major ones being the materials dissolved in their waters, the climate of the region, energy exchanges with the atmosphere, the soil and the variety of organisms inhabit them, all of which are influenced by, and also influence, the lake system itself. This complexity means that when a lake is studied on the basis of a single discipline, it can often lead to misleading conclusions, or even incorrect results. Multidisciplinary is a keyword in regard to this conference, different approaches and point of views also must be taken into account to address complex lake issues. Therefore, we are inviting not only scientists, but also resource managers, politicians, and lake basin stakeholders and users to the conference. The interactions among this diverse audience will result in a wider discussion, with the goal of connect a top-down approach to a bottom-up perspective to solving complex lake basin issues.

ISBN: 978-88-96504-07-9

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